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REPORT

TO

ALBERTA ENVIRONMENT

ON

[illegible]

# HYDROGEOLOGICAL ASSESSMENT OF THE PROPOSED PINE COULEE RESERVOIR

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## TABLE OF CONTENTS

PAGE NO.

1. INTRODUCTION 1
   - 1.1 TERMS OF REFERENCES 1
   - 1.2 LOCATION, CLIMATE AND TOPOGRAPHY 2

2. GEOLOGIC SETTING 4
   - 2.1 BEDROCK GEOLOGY 4
   - 2.2 SURFICIAL DEPOSITS 4
   - 2.3 HYDROGEOLOGIC SETTING 5
     - 2.3.1 Hydrogeology 5
     - 2.3.2 Hydrochemistry 6

3. FIELD EXPLORATION PROGRAM 7
   - 3.1 OBJECTIVES 7
   - 3.2 PIEZOMETER INSTALLATION 7
     - 3.2.1 Layout and Design 7
     - 3.2.2 Drilling 8
     - 3.2.3 Piezometer Construction 9
     - 3.2.4 Piezometer Development and Hydraulic Conductivity Tests 10
   - 3.3 WATER SUPPLY WELLS 11
   - 3.4 FIELD MAPPING 12

4. RESULTS OF THE FIELD EXPLORATION PROGRAM 13
   - 4.1 GEOLOGY 13
   - 4.2 HYDROGEOLOGY 13

## TABLE OF CONTENTS (Cont'd)

PAGE NO.

5. HYDROGEOLOGIC EVALUATIONS 16
  5.1 ESTIMATE OF POTENTIAL WATER LOSSES FROM THE RESERVOIR 16
    5.1.1 Losses Through the Valley Bottom 16
    5.1.2 Losses Into the Valley Walls 17
    5.1.3 Seepage Losses Underneath the East Bank Dyke 19
  5.2 PROGNOSIS OF GROUNDWATER SURFACE ELEVATIONS IN THE AREAS ADJACENT TO THE RESERVOIR 19
    5.2.1 The Range of Influence of the Reservoir 19
    5.2.2 Changes in Surrounding Groundwater Surface Elevations 20
  5.3 POTENTIAL ADVERSE AFFECTS OF THE RESERVOIR ON THE SURROUNDING AREAS 20
    5.3.1 Changes in the Local Groundwater Quality 21
    5.3.2 Flooding in Areas of Low Topography 21

6. CONCLUSIONS 22

7. RECOMMENDATIONS 24

8. REFERENCES 26

APPENDIX I: SITE SURVEY RESULTS
II: BOREHOLE LOGS AND PIEZOMETER COMPLETION DETAILS
III: WATER LEVEL MEASUREMENTS AND HYDRAULIC CONDUCTIVITY TESTS
IV: LOCAL WATER SUPPLY WELLS

## LIST OF TABLES

| TABLE NO. | TITLE |
|---|---|
| 1 | HYDRAULIC CONDUCTIVITIES |
| 2 | WATER LOSSES THROUGH THE VALLEY BOTTOM |
| 3 | WATER LOSSES INTO EAST VALLEY WALL |
| 4 | SEEPAGE LOSSES UNDERNEATH THE EAST BANK DYKE |

# LIST OF FIGURES

| FIGURE NO. | TITLE |
|---|---|
| 1 | DAM, RESERVOIR AND EAST BANK DYKE LOCATIONS |
| 2 | SURFICIAL GEOLOGY IN THE RESERVOIR AREA |
| 3 | PIEZOMETER, WELL AND SPRING LOCATIONS |
| 4 | GROUNDWATER SURFACE ELEVATIONS |
| 5 | HYDROGEOLOGICAL CROSS-SECTION AA' (5558450 N) |
| 6 | RANGE OF INFLUENCE OF RESERVOIR USING RECHARGING WELL ANALOGY |

# 1. INTRODUCTION

## 1.1 TERMS OF REFERENCE

Alberta Environment (Planning Division) is reviewing the feasibility of an earthfill dam in the Pine Coulee. The purpose of this dam would be to provide off-stream water storage in the Willow Creek drainage basin. Water for storage would be diverted from Willow Creek by both natural drainage courses and an excavated channel. The resulting Pine Coulee reservoir would have a maximum depth, at the dam, of approximately 21 m.

Piteau Engineering has been retained to assess the hydrogeological conditions in the reservoir area. In particular, the purpose of the study, as outlined in our proposal dated July 19, 1985, is to:

1. Establish a groundwater monitoring system around the proposed reservoir.
2. Assess potential water losses from the reservoir into the surrounding geological formations.
3. Predict the distance at which groundwater surface elevations will be affected by reservoir impoundment.
4. Delineate areas where local flooding may occur as a result of rising groundwater surface elevations.

This report describes the work and testing performed by Piteau Engineering Ltd. The field program was conducted from August 8 - 30, 1985, inclusive. Drilling was performed by Allkind Drilling Ltd. and the site survey was carried out by D.A. Watt Consulting Group Ltd.

Piteau Engineering Ltd. acknowledges the help of Messrs. Don Prosser, John Campbell and Dan Hubbard of Alberta Environment on this project.

## 1.2 LOCATION, CLIMATE AND TOPOGRAPHY

The proposed location of the Pine Coulee dam is 600 m upstream of the junction of the Pine and Willow Creeks, in S.W. 34, TWP 13, RGE 28, W4M. The reservoir would extend north for approximately 12.8 km into SEC 3, TWP 15, RGE 28, W4M (Figure 1). The damsite and reservoir are situated about 6 km due west of the town of Stavely.

The mean January, July and annual temperatures at Gleichen, to the north, are -12.2°C, 17.9°C and 3.5°C, respectively. The mean January, July and annual temperatures at Vauxhall, to the east, are -10.7°C, 18.9°C and 4.3°C, respectively (Canada Department of Transport, Meteorological Branch, 1967). The mean annual precipitation is 419 mm and the annual potential evapotranspiration is approximately 762 mm near Claresholm (Ozoray and Lytviak, 1974). Hence, the potential evapotranspiration is approximately 1.8 times the precipitation.

The dam and reservoir lie on the western edge of the Interior Plains physiographic region, near the Porcupine Hills. Surface water, aided by low infiltration rates, runs eastward from these hills towards the Willow Creek and Pine Coulee area. Local relief is subdued, with the exception of the north-trending Pine and Willow Creek valleys, which are incised some 25 - 35 m into the uplands above the valleys. Both the Pine and Willow Creeks belong to the Oldman Drainage Basin.

Shallow sloughs and lakes are common in this area and are subject to high seasonal fluctuations both in water surface elevations and areal extent. They are occasionally brackish and frequently have salt-crusted shorelines.

# 2. GEOLOGIC SETTING

## 2.1 BEDROCK GEOLOGY

Bedrock in the reservior area belongs primarily to the Lower Tertiary Porcupine Hills Formation, which consists of pale grey, calcareous sandstone interbedded with pale grey calcareous mudstone. This is underlain by the Lower Tertiary/Upper Cretaceous Willow Creek Formation, which consists of interbedded grey calcareous sandstone and bentonite mudstone, with occasional thin beds of limestone. The remaining thickness of the Porcupine Hills Formation varies from approximately 200 m to the west of the reservoir to 0 m a few kilometres to the east, where the Willow Creek Formation forms the bedrock surface. The Willow Creek Formation also varies in thickness from east to west, but is approximately 500 m underneath the Pine Coulee (Ozoray and Lytviak, 1974).

The depth of the bedrock surface in the reservoir area is shallow. Bedrock topography can vary from actual outcrops to depths of 20 - 30 m over a distance of a few hundred metres. The bedrock is intermittently exposed on the uplands and in river valley slopes that have been eroded. Outcroppings are more numerous to the west, and 5 - 6 km away, the bedrock rises to form the topographically diverse Porcupine Hills.

## 2.2 SURFICIAL DEPOSITS

In the bottom of Pine Coulee, surficial deposits are represented by approximately 10 m or more of clay with interbedded sand, silt and occasional gravel (Figure 2). These sediments are of glaciofluvial or post-glacial alluvial origin (Alberta Environment Memorandum, June 4, 1984). Colluvium on the valley slopes was derived mostly from glacial or alluvial material.

On the uplands surrounding the Pine Coulee, clayey or silty till is present and may exceed 30 m in thickness (Figure 2). Occasional lenses of silt and sand are present within the till. According to Alberta Environment (Memorandum, dated June 4, 1984), the till to the west of the valley was extensively modified by glacial meltwater, in some places being completely eroded and leaving boulders on the surface. Meltwater channels were incised through the glacial deposits, into bedrock, and subsequently infilled with glaciofluvial materials such as clays, silts and sands. The granular deposits in the gravel pit located in SW5, TWP 14, RGE 28, W4M are likely derived from these glaciofluvial materials.

Towards the south end of the reservoir, approximately 400 m northeast of the dam centreline, the Stavely Buried Channel trends from west to east (Figure 2). This channel is infilled with preglacial sands and gravels up to 6 m thick and is now buried by approximately 15 m of alluvial or glacial deposits. According to Geiger (1968), the Stavely Buried Channel was part of the Lethbridge Valley system, which provided drainage in southern Alberta during preglacial time. A tributary of this channel also coincided with the present course of the Pine Coulee (Geiger, 1968).

## 2.3 HYDROGEOLOGIC SETTING

### 2.3.1 Hydrogeology

The regional groundwater flow in the Pine Coulee area is towards the east. Locally, the Pine Coulee acts as a drainage area intercepting surface water and shallow groundwater flow.

The term hydrostratigraphic unit describes water-bearing zones of similar groundwater recharge circulation and hydrochemical conditions. A lower (bedrock) hydrostratigraphic unit is represented by the Porcupine Hills Formation. The various surficial fine-grained deposits of glacial and/or alluvial origin form an upper hydrostratigraphic unit. This unit contains various higher hydraulic conductivity lenses of silt and/or sand. Drilling records obtained from Alberta Environment indicate that these lenses are generally near-surface and discontinuous.

The hydraulic conductivities of these units have been determined by Alberta Environment (1985) to be low, with values commonly less than 1 x $10^{-7}$ m/s indicating slow groundwater movement. Ozoray and Lytviak (1984) have estimated the 20-year safe yields of these units to be no greater than 1.67 l/s for the Porcupine Hills Formation and no greater than 0.42 l/s for the surficial materials. Neither unit is considered an important regional water source.

A third hydrostratigraphic unit on site is represented by the preglacial sands and gravels of the Stavely Buried Channel. The exact nature and extent of this deposit is unknown, but 20-year safe yields may be as high as 7.50 l/s (Ozoray and Lytviak, 1984).

### 2.3.2 Hydrochemistry

Groundwater in the region commonly ranges between 500 and 1000 mg/l in total dissolved solids (TDS). This range of values is typical of groundwater in southern Alberta. Waterwell records in the Pine Coulee area indicate that the groundwater is a soft, sodium-bicarbonate type. This typifies a mature water where natural softening has occurred with age and sodium has replaced calcium in a cation exchange process. The chloride content, in milliequivalents, is usually less than 10%.

# 3. FIELD EXPLORATION PROGRAM

## 3.1 OBJECTIVES

The primary objectives of the field exploration program were to define groundwater surface elevations in the reservoir area and to determine the hydraulic conductivities of the local geologic units. With this information, a qualitative and quantitative evaluation of the integrity of the proposed reservoir could be made.

## 3.2 PIEZOMETER INSTALLATION

### 3.2.1 Layout and Design

Sixteen piezometer nests (A - Q, excluding E), totalling 32 piezometers, were constructed on site (Figure 3). A piezometer was not installed in Hole E because drilling penetration was minimal. Each nest was denoted with a letter, rather than a number, to avoid confusion with holes drilled during previous studies by Alberta Environment and PFRA. Eleven nests were located around the perimeter of the reservoir and five nests were located in the Pine Coulee. Of the latter five nests, four (A, B, C and D) were drilled at the south end of the reservoir to delineate the Stavely Buried Channel. The remaining nest (Q) was drilled to locate the groundwater surface and further define the geology at the north end of the reservoir. No drillholes were located on the slopes of the Pine Coulee, due to difficulty in accessing these areas with a drill rig. A backhoe would be ideally suited for test pitting on the slopes and should be considered in future hydrogeological investigations. Survey coordinates for each piezometer are given in Appendix I.

An upper and lower piezometer was usually installed at each site in order to determine groundwater surface elevations and vertical hydraulic gradients. However, in two nests (A and J), 3 piezometers were installed and in a further two nests (F and P), only 1 piezometer was installed. This was in response to local hydrogeologic conditions. In order to assure hydraulic isolation, individual piezometers were installed in separate drillholes.

### 3.2.2 Drilling

Drilling was carried out using a B-61 truck-mounted continuous flight auger rig. The rig was supplied and operated by Allkind Drilling Ltd. of Calgary. This type of rig accommodated drilling in fine-grained, unconsolidated formations. Also, as no drilling fluids were used, the possibility of introducing contaminants was minimized.

Both the hollow stem auger (HSA) and the solid stem auger (SSA) were used for drilling due to difficult conditions encountered. The HSA was used in the Pine Coulee where caving of the drillholes was a problem and the SSA was used for shallow holes, where caving was not a problem. The SSA was also used for deeper holes on the uplands, where the HSA could not effectively penetrate gravelly (till) deposits. Since the SSA had to be removed from the hole prior to installation of a piezometer, leaving an open hole prone to caving, the maximum depth of installation was therefore limited.

Samples were usually taken every 1.5 or 3 m during drilling and were classified according to the Modified Unified System Classification of Soils for Engineering Purposes (Modified USC).

When drilling with the hollow stem auger, samples were obtained through the drill stem by removing the bit and inserting a Shelby or a splitspoon tube. Samples recovered this way were relatively undisturbed. When drilling with the solid stem auger, samples were obtained by withdrawing the entire drill string and examining the material on the bit. Samples recovered this way were relatively disturbed. The borehole logs are presented in Appendix II.

### 3.2.3 Piezometer Construction

The piezometers were either installed through the hollow stem auger or, if the hole was drilled with the solid stem, in the hole after the drill string was withdrawn. A piezometer tip consisting of 51 mm of machine slotted, schedule 40 PVC pipe (3 rows, 0.020 inch) was placed in the drillhole. The annulus around the piezometer screen was then packed with a graded (12/20) Frac sand. A bentonite seal was placed above the sand pack to prevent leakage from above the hole and the remaining annulus to near ground level was infilled with drill cuttings mixed with bentonite pellets. When the piezometer tip was completed in a zone above the bottom of the hole, a bentonite seal was first placed below the tip to assure hydraulic isolation.

A 1.5 m long, 152 mm diameter protective steel casing was inserted at the surface to protect each piezometer from damage. This casing was complete with a locking steep cap. A cement plug was also placed around the casing to prevent inflow of surface runoff. These casings were frequently located (by necessity) in the ditches next to roadways and should therefore be periodically inspected for damage and the cement plug maintained. Piezometer construction details are given in Appendix II.

### 3.2.4 Piezometer Development and Hydraulic Conductivity Tests

All piezometers containing water were developed by flushing out the water column. This was usually performed by nitrogen purging. Either 6 mm plastic tubing or 19 mm PVC pipe, depending on the development required, was placed at selected depths below the water level and nitrogen applied under pressure. In this way, silty and/or clayey material was drawn into the piezometer and then discharged with the water. In piezometers with insufficient water to purge, development was carried out by bailing. Bailing provides a surging action which results in the removal of fine material.

Hydraulic conductivity tests were performed on all functioning piezometers and the data was reduced using the standard method of Hvorslev (1951). Generally, falling head tests were used in piezometers above the groundwater surface and rising head tests were used in piezometers below the groundwater surface. In these tests, water is either poured into or bailed out of the piezometer and the water level rise or fall is measured with time.

The data from a hydraulic conductivity test is representative of only the zone in the immediate vicinity of the piezometer because a relatively small volume of water is removed or added. Also, this zone may be disturbed by drilling and installation procedures. Small variations in clay content can greatly change the K value of otherwise permeable geologic deposits. Therefore, values of K from this type of test are only approximate.

The water for falling head tests was acquired from local sources, such as the town of Claresholm, Willow Creek and farmer's wells. This method is not ideal as the chemical nature of the water in the piezometer may be altered. However, because those piezometers in which falling head tests were performed were usually dry, they would likely not be sampled in a hydrochemical program. The hydraulic conductivity tests and calculations are given in Appendix III.

## 3.3 WATER SUPPLY WELLS

A survey of local water supply wells was also undertaken (Figure 3). The well logs are presented in Appendix IV. Frequently, each farm had two wells, one for domestic use and one for agricultural purposes. The wells were usually completed in bedrock, at a depth varying from less than 30 m to greater than 60 m. Yields from these wells rarely exceed 1.67 l/s and are commonly less than 1.25 l/s.

Interviews with the farmers in the area revealed that in recent years, water levels have declined substantially and many new wells have had to be drilled. This is probably in response to three years of consecutive drought and therefore, reduced groundwater recharge.

## 3.4 FIELD MAPPING

Hydrogeologic field mapping of the Pine Coulee and surrounding area was performed during and after the drilling program.

In the Pine Coulee, at the north end of the reservoir, groundwater is at the ground surface, while near the dam location, groundwater was 5 - 6 m below surface. Two springs were also mapped at the north end of the Pine Coulee on the east bank (Figure 3).

Surface water was restricted to shallow lakes and sloughs on the uplands. Several of these have been completely evaporated or drained as a result of reduced precipitation in recent years. For example, the large lake in SEC 25 and 36, TWP 13, RGE 28, W4M has been completely drained for agricultural purposes.

Many of the existing dugouts, which provide water for cattle, on the uplands were dry and new, deeper dugouts were being constructed. These dugouts are above the groundwater surface and rely on rainfall which is then retained by the relatively impervious underlying till. Dugouts in the Pine Coulee were below the groundwater surface and contained water.

Bedrock outcrops were usually limited to elevations above the proposed reservoir full supply level (F.S.L.), with the exception of small exposure in creek beds on the banks of the Pine Coulee. These outcrops typically consist of sandstone and shale, with shale being preferentially removed by weathering.

Much of the upland ground surface was covered with boulders which were derived from eroded till moraine. These boulders were sub-rounded, up to 30 cm in diameter, and of a varied genesis.

# 4. RESULTS OF THE FIELD EXPLORATION PROGRAM

## 4.1 GEOLOGY

The stratigraphic units encountered during the drilling program were consistent with those described in the literature. Bedrock (P-P1 and M-P1) underlying the study area was either sandstone or shale (mudstone), typical of the Porcupine Hills Formation.

Quaternary deposits (e.g., O-P1 and H-P1) on the uplands consisted of 0, to greater than 30 m of silty clay with sub-rounded boulders and occasional, near surface gravel, sand or silt layers. This sequence is likely a till moraine that has been altered by erosional processes at the top (Figure 4). Quaternary deposits in the Pine Coulee (e.g., A-P2 and B-P2) consisted of 9 m or more of silty clay with occasional, discontinuous sand and/or silt lenses throughout. This sequence is likely a glacialfluvial or alluvial deposit (Figure 4).

In the Pine Coulee, an east-west band of sand and gravel, more than 10 m thick in places, (A-P1 and B-P1) was encountered. This band is approximately 400 m wide and covered by 13 - 16 m of silty clay. A water well (Figure 3, Well #1) some 325 m east of piezometer B-P1 was previously completed in 6.5 m of the sand and gravel above the bedrock. This deposit is likely the preglacial sand and gravel of the Stavely Buried Channel.

## 4.2 HYDROGEOLOGY

The results from hydraulic conductivity tests are listed in Table 1. These results indicate that the silty clay, of glacial or alluvial

# TABLE 1.

## HYDRAULIC CONDUCTIVITIES

| PIEZOMETER | COMPLETION ZONE | MATERIAL PIEZOMETER COMPLETED IN | HYDRAULIC CONDUCTIVITY (m/s) | TEST USED |
|---|---|---|---|---|
| A-P1 | 17.53 - 20.57 | Clayey Gravel | $5.0 \times 10^{-7}$ | Bail |
| A-P2 | 13.56 - 15.09 | Silty Clay with Sand Lenses | $4.2 \times 10^{-6}$ | Bail |
| A-P3 | 5.79 - 6.71 | Silty Clay with Silt Lenses | $1.3 \times 10^{-6}$ | Bail |
| B-P1 | 14.33 - 17.37 | Clayey Gravel and Sand | $4.9 \times 10^{-6}$ | Bail |
| B-P2 | 4.57 - 7.62 | Silty Clay | $1.9 \times 10^{-9}$ | Bail |
| C-P1 | 10.52 - 12.04 | Silty Clay | | |
| C-P2 | 3.96 - 5.49 | Silty Clay with Sand Lenses | piezometer not functioning | Piezometer not functioning |
| D-P1 | 10.21 - 11.73 | Sandstone | $6.6 \times 10^{-9}$ | Slug |
| D-P2 | 5.79 - 7.32 | Silty Clay | $6.7 \times 10^{-8}$ | Bail |
| F-P1 | 5.18 - 6.71 | Clayey Silt | $7.5 \times 10^{-7}$ | Bail |
| G-P1 | 6.10 - 7.62 | Clayey Silt | $1.9 \times 10^{-8}$ | Bail |
| G-P2 | 26.97 - 30.02 | Silty Clay | $9.6 \times 10^{-9}$ | Slug |
| H-P1 | 10.36 - 13.41 | Silty Clay with Sand Laminae | $3.4 \times 10^{-7}$ | Bail |
| H-P2 | 2.44 - 3.96 | Silty Sand | $1.9 \times 10^{-8}$ | Bail |
| I-P1 | 7.01 - 8.53 | Clayey Silt with Sandstone Layers | $3.1 \times 10^{-8}$ | Slug |
| I-P2 | 2.90 - 4.42 | Clayey Silt | $1.6 \times 10^{-7}$ | Slug |
| J-P1 | 5.49 - 7.01 | Silty Clay with Fe-Stained Joints | $3.3 \times 10^{-8}$ | Slug |
| J-P2 | 2.74 - 4.27 | Silty Clay | $6.6 \times 10^{-9}$ | Bail |
| J-P3 | 18.29 - 21.34 | Silty Clay | $9.0 \times 10^{-8}$ | Slug |
| K-P1 | 3.05 - 4.57 | Clayey Silt | $1.4 \times 10^{-9}$ | Bail |
| K-P2 | 13.11 - 14.63 | Silty Clay | $8.3 \times 10^{-9}$ | Slug |
| L-P1 | 13.41 - 14.94 | Silty Clay | $3.4 \times 10^{-9}$ | Slug |
| L-P2 | 3.05 - 4.57 | Silty Clay | $6.6 \times 10^{-10}$ | Slug |
| M-P1 | 12.04 - 12.65 | Shale | $5.2 \times 10^{-8}$ | Slug |
| M-P2 | 3.05 - 4.57 | Silty Clay and Shale | $1.1 \times 10^{-9}$ | Slug |
| N-P1 | 9.75 - 14.33 | Silty Clay and Shale | $8.0 \times 10^{-9}$ | Slug |
| N-P2 | 2.74 - 3.66 | Clayey Gravel | $7.4 \times 10^{-10}$ | Bail |
| O-P1 | 13.11 - 14.63 | Silty Clay | $2.0 \times 10^{-6}$ | Slug |
| O-P2 | 2.74 - 3.66 | Clayey Gravel | $1.1 \times 10^{-8}$ | Bail |
| P-P1 | 14.78 - 17.83 | Silty Clay | $3.3 \times 10^{-6}$ | Slug |
| Q-P1 | 1.37 - 2.29 | Silty Clay | $8.9 \times 10^{-9}$ | Slug |
| Q-P2 | 6.71 - 8.23 | Silty Clay with Silt Laminae | $9.6 \times 10^{-10}$ | Slug |
| | | | $1.0 \times 10^{-5}$ | Bail |

origin, which overlies the site, has a low hydraulic conductivity (K) ranging from 7.5 x $10^{-7}$ m/s (D-P2) to 6.6 x $10^{-10}$ m/s (L-P1). Contained within the silty clay are occasional silt, sand and gravel lenses of intermediate K, ranging from 1.0 x $10^{-5}$ (Q-P2) to 4.2 x $10^{-6}$ m/s (A-P2). Drilling from this study, and previous drilling by Alberta Environment, indicates that these lenses are either discontinuous or near-surface and are likely of limited hydrogeological importance.

The Stavely Buried Channel was tested twice for hydraulic conductivity and has intermediate values of 4.9 x $10^{-6}$ (B-P1) to 5.0 x $10^{-7}$ (A-P1). These tests represent a small portion of this aquifer. Interviews with the owner of Well #1, which was completed in the Stavely Buried Channel, revealed that the well was tested at over 2.65 l/s when completed. Bedrock (sandstone and shale) was also tested twice for hydraulic conductivity and has low values of 6.7 x $10^{-8}$ (D-P1) to 1.1 x $10^{-9}$ (M-P1). These measurements are representative of only the top 1 m or so of bedrock. They are in rough agreement with hydraulic conductivity tests performed by Alberta Environment (Memorandum, June 12, 1985) on two previous boreholes in bedrock. However, further limited testing is advisable in order to more completely sample bedrock throughout the reservoir area.

Both the bedrock and the Stavely Buried Channel would probably be hydraulically separated from th reservoir by the overlying silty clay. However, if a hydrogeological window opened between the reservoir and the Stavely Channel, the latter may have the potential to act as a drain. Therefore, it is advisable that a more representative test, such as an aquifer test, be conducted to determine the hydraulic properties of the channel.

Groundwater surface elevations were measured in late August, 1985 (Figure 4) and are related to the bedrock topography. Groundwater surface elevations near topographic highs, such as bedrock outcrop on the west side, are usually the greatest (Figure 5). These measurements indicate that the groundwater surface was 1085.31 m at N-P1 to the west of Pine Coulee. To the east, the groundwater surface was 1048.51 m at O-P1. However, the elevations measured during the field program are likely lower than normal due to three factors:

1. The measurements were taken during the period of low seasonal groundwater surface elevations;
2. The measurements were taken after 3 years of drought; and,
3. Many piezometers were completed in very low K material and require extended periods of time to stabilize.

Groundwater surface elevations in the Stavely Buried Channel indicate that it is a confined aquifer with an excess head of 7.5 - 12 m. Flowing or artesian conditions were not encountered in Piteau drillholes that intercepted this aquifer.

Horizontal hydraulic gradients calculated on the uplands range from 0.01 to 0.03 in magnitude and generally trend towards the Pine Coulee. Vertical hydraulic gradients in the reservoir area are generally downwards, indicating groundwater recharge. The horizontal gradient calculated for the Stavely Buried Channel was approximately 0.002 towards the east. However, this was based on measurements from only two piezometers (A-P1 and B-P1) situated some 355 m apart and assumed that the channel was linear. Further piezometer installations in the Stavely Buried Channel are therefore advisable for the accurate determination of hydraulic gradients and flow velocities.

# 5. HYDROGEOLOGIC EVALUATIONS

## 5.1 ESTIMATE OF POTENTIAL WATER LOSSES FROM THE RESERVIOR

Potential water losses from the proposed reservoir may occur as a result of seepage:

1. Through the valley bottom and into the underlying geological formations;
2. Through the valley walls into the silty clay till and bedrock deposits; and,
3. Underneath the east bank dyke.

### 5.1.1 Losses Through The Valley Bottom

Water from the reservoir can be expected to seep downwards through the silty clay deposits which line the reservoir and dissipate into the underlying bedrock and the Stavely Buried Channel deposits. Estimates of this loss, using Darcy's Law, are given in Table 2.

The cross-sectional area of the reservoir bottom will vary between about 6,400,000 $m^2$ and 4,000,000 $m^2$ at the Full Supply Level (F.S.L.) and the Minimum Supply Level (M.S.L.), respectively. The hydraulic gradient will be a maximum at the dam site and decrease linearly along the length of the valley to a value of zero at the north end, thus approximating a triangular distribution. This vertical gradient will vary between a maximum of 0.70 (F.S.L.) and 0.30 (M.S.L.), for an average thickness of 10 m for the silty clay deposit and a groundwater surface 3 m below the ground elevation.

## TABLE 2.

## WATER LOSSES THROUGH THE VALLEY BOTTOM

| RESERVOIR SUPPLY LEVEL | VERTICAL HYDRAULIC CONDUCTIVITY (m/s) | AVERAGE HYDRAULIC GRADIENT | CROSS-SECTIONAL AREA ($m^2$) | WATER LOSS RATE ($m^3/s$) |
|---|---|---|---|---|
| Minimum | $5.0 \times 10^{-8}$ | 0.30 | 4,000,000 | 0.06 |
| Minimum | $2.5 \times 10^{-8}$ | 0.30 | 4,000,000 | 0.03 |
| Minimum | $5.0 \times 10^{-9}$ | 0.30 | 4,000,000 | 0.01 |
| Full | $5.0 \times 10^{-8}$ | 0.70 | 6,400,000 | 0.22 |
| Full | $2.5 \times 10^{-8}$ | 0.70 | 6,400,000 | 0.11 |
| Full | $5.0 \times 10^{-9}$ | 0.70 | 6,400,000 | 0.02 |

The value of hydraulic conductivity, K, which is appropriate for downward flow is K vertical, which is assumed to be 1/2 K horizontal due to the anisotropy inherent in sedimentary deposits. K horizontal, as determined by the hydraulic conductivity tests, is in the order of $1.0 \times 10^{-7}$ to $1.0 \times 10^{-8}$ m/s (based on a weighted average of conductivities for the silty clay, including high permeability silt, sand and gravel lenses).

Table 2 shows that water losses will likely vary between 0.01 and 0.06 $m^3/s$ at the M.S.L., and 0.02 and 0.22 $m^3/s$ at the F.S.L., depending on K. Therefore, maximum losses should not exceed 0.06 and 0.22 $m^3/s$ while the reservoir is at the M.S.L. and F.S.L., respectively. Average losses through the valley bottom will depend on the duration the reservoir is full, or depleted, during a yearly cycle.

Assuming that the reservoir is at the F.S.L. for no more than 3 months (one quarter) of any 1 year, the loss rate would average approximately 0.10 $m^3/s$. Assuming that the reservoir is at the F.S.L. for no more than 6 months (one half) of any 1 year, the loss rate would average approximately 0.14 $m^3/s$. This latter rate is the maximum seepage rate expected through the valley bottom, based on the geological conditions found.

### 5.1.2 Losses Into the Valley Walls

Short term losses into the valley walls will consist primarily of water lost in saturating previously dry deposits during the initial raising of the reservoir. These losses will occur only once during the lifetime of the reservoir and due to the low hydraulic conductivity of the surrounding material, will take place over several years. The total volume of water lost due to saturation of the surficial deposits is very difficult to determine. It is expected, however, that this loss will be negligible.

Long-term groundwater leakage through the valley walls is likely to be minimal due to the high level of the surrounding groundwater surface. The present level of the groundwater surface on the west side of the valley is above the full supply level (F.S.L. = 1054 m a.s.l.) of the reservoir (see Figure 5). Water from the reservoir will flow west until it meets this surface and then flow will be retained. The present level of the groundwater surface on the east side of the valley is below the reservoir F.S.L., but generally above the minimum supply level (M.S.L. = 1046 m a.s.l.) (see Figure 5). Therefore, water will flow east when the reservoir is full and then drain back towards the reservoir when the level is lowered to the minimum supply level.

The total volume of these flows will depend upon the time the reservoir will be above and below the surrounding groundwater elevation. This information is not available at this time. However, a conservative estimate of water losses can be made by ignoring the flow back into the reservoir during periods of low storage.

Table 3 gives an estimate of the rates of these losses using a range of horizontal K ($1 \times 10^{-7}$ to $1 \times 10^{-8}$ m/s) for the surrounding silty clay and bedrock deposits. The cross-sectional area through which the water would flow east is about 102,400 $m^2$ and the horizontal gradient would likely be no greater than 0.01. Based on these assumptions, the maximum water loss should not exceed $1.0 \times 10^{-4}$ $m^3/s$. In comparison to the total volume of the reservoir, this loss can be considered negligible.

TABLE 3.

WATER LOSSES INTO EAST VALLEY WALL

| HORIZONTAL HYDRAULIC CONDUCTIVITY (m/s) | HYDRAULIC GRADIENT | CROSS-SECTIONAL AREA ($m^2$) | WATER LOSS RATE ($m^3/s$) |
|---|---|---|---|
| $1.0 \times 10^{-7}$ | 0.01 | 102,400 | $1.0 \times 10^{-4}$ |
| $5.0 \times 10^{-8}$ | 0.01 | 102,400 | $5.1 \times 10^{-5}$ |
| $1.0 \times 10^{-8}$ | 0.01 | 102,400 | $1.0 \times 10^{-5}$ |

### 5.1.3 Seepage Losses Underneath the East Bank Dyke

Seepage losses underneath the proposed east bank dyke, near the south end of the reservoir, are also possible due to the high local gradients caused by the dyke. Table 4 shows a range of seepage rates using a range of horizontal K ($1 \times 10^{-7}$ to $1 \times 10^{-8}$ m/s) for the underlying silty clay.

The cross-sectional area for flow underneath the dyke is about 50,000 $m^2$ and the horizontal gradient would likely be no greater than 0.5. Based on these assumptions, the maximum water loss should not exceed $3.0 \times 10^{-3}$ m/s. In comparison to the total volume of the reservoir, this rate of loss can also be considered negligible.

## 5.2 PROGNOSIS OF GROUNDWATER SURFACE ELEVATIONS IN THE AREAS ADJACENT TO THE RESERVOIR

### 5.2.1 The Range of Influence of the Reservoir

To estimate the range of influence that the reservoir will have on the surrounding groundwater surface elevations, an empirical formula described by Pazdro (1977) was used. This formula models the reservoir as a recharging well in an unconfined aquifer (Figure 6). The range of influence was dependent on the hydraulic conductivity of the surrounding silty clays and was found not to exceed 100 m.

This is a simplistic approach, but provides an estimate of the range of influence of the reservoir to be expected. Real values may be higher, but should not exceed several hundred metres in any case. Thus, changes in the groundwater surface elevation

## TABLE 4.

## SEEPAGE LOSSES UNDERNEATH EAST BANK DYKE

| HORIZONTAL HYDRAULIC CONDUCTIVITY (m/s) | HYDRAULIC GRADIENT | CROSS-SECTIONAL AREA ($m^2$) | SEEPAGE RATE ($m^3/s$) |
|---|---|---|---|
| $1.0 \times 10^{-7}$ | 0.5 | 50,000 | $3.0 \times 10^{-3}$ |
| $5.0 \times 10^{-8}$ | 0.5 | 50,000 | $1.0 \times 10^{-3}$ |
| $1.0 \times 10^{-8}$ | 0.5 | 50,000 | $2.5 \times 10^{-4}$ |

will be limited to narrow band paralleling the Pine Coulee and of approximately the same width.

### 5.2.2 Changes in Surrounding Groundwater Surface Elevation

Any changes in the elevation of the surrounding groundwater surface should be upwards, because the reservoir will add water to the local groundwater regime. The maximum rise of the groundwater surface will be equal to the depth of the reservoir at the dam (21 m), since the groundwater is at, or near, the ground surface in the valley at present. Groundwater surface rises will be less northward along the Pine Coulee due to the decreasing depth of the reservoir. Groundwater surface rises will also decrease away from the Pine Coulee.

Since the present groundwater surface on the east side of the valley is slightly below the proposed F.S.L. of the reservoir, the groundwater regime on this side may be slightly altered. In particular, the groundwater divide may be moved eastward in response to reduced groundwater flow towards the reservoir. However, this should not adversely affect the reservoir level or the surrounding groundwater regime.

## 5.3 POTENTIAL ADVERSE EFFECTS OF THE RESERVOIR ON THE SURROUNDING AREAS

There are two potential problems which may result from the reservoir impoundment:

1. Changes in the local groundwater quality; and,
2. Flooding in areas of low topography.

### 5.3.1 Changes in the Local Groundwater Quality

Seasonal fluctuations in the groundwater surface will occur due to the raising and lowering of the reservoir level. The cyclic aeration and saturation caused by these fluctuations may lead to an increase in concentrations of Fe, Mn and metals and, thus, localized degradation of the groundwater quality. However, due to the low hydraulic conductivity of the silty clay deposits, it is probable that seasonal fluctuations will be small and thus, any degradation can be expected to be minimal.

The introduction of water, diverted from Willow Creek into the local groundwater regime, may affect the quality of the local groundwater, depending on the hydrochemical characteristics of both waters. It is likely, however, that any impact will be beneficial because the Willow Creek water is good quality.

### 5.3.2 Flooding in Areas of Low Topography

The only areas where flooding appears possible is east of the proposed east bank dyke, near the south end of the reservoir (Figure 1). This area has ground and groundwater surface elevations less than either the F.S.L. or M.S.L. of the reservoir. However, groundwater flow through the silty clay under the proposed dyke has already been estimated to be minimal. Therefore, flooding should not be a serious problem. To ensure that the minimal seepage under the dyke does not cause even localized flooding, it is advisable to construct a drainage system to collect and drain any surface, or near surface, water.

# 6. CONCLUSIONS

6.1 The entire site appears to be lined with a low hydraulic conductivity silty clay (K = $1.0 \times 10^{-7}$ to $1.0 \times 10^{-8}$ m/s) of glacial or alluvial origin. The underlying bedrock was tested twice for hydraulic conductivity and had a low K of $6.7 \times 10^{-8}$ to $1.1 \times 10^{-9}$ m/s.

6.2 The Stavely Buried Channel was tested twice during the field program for hydraulic conductivity and had an intermediate K of $4.9 \times 10^{-6}$ to $5.0 \times 10^{-7}$ m/s. This channel is a confined aquifer and is overlain by low hydraulic conductivity silty clay, which likely hydraulically separates it from the proposed reservoir. However, the extent and hydrogeological properties of the channel are unproven and it may have the potential to act as a drain if a hydrogeological window opens to the reservoir.

6.3 Water losses from the reservoir into surrounding geological formations would be primarily through the valley bottom and should not exceed 0.14 $m^3/s$. Water losses through the valley walls and underneath the east bank dyke area will likely be less than $1.0 \times 10^{-3}$ $m^3/s$.

6.4 A rise in groundwater surface elevations will occur in the areas adjacent to the reservoir and will be less than the maximum depth of 21 m of the reservoir. Due to the low hydraulic conductivity values of the surrounding geologic formations, the radius of influence of the reservoir on the groundwater surface elevation should be limited to, at most, several hundred metres.

6.5 Flooding in areas adjacent to the valley will not likely be a problem due to the high ground surface relative to the proposed reservoir level. East of the proposed east bank dyke, where the ground and groundwater surface is lower than the reservoir level, minimal seepage may occur. If a proper drainage system is constructed, any near surface and surface flow can be intercepted and flooding will likely not occur.

6.6 The quality of the groundwater surrounding the reservoir will likely be minimally affected by the introduction of new water to the groundwater regime and by seasonal fluctuations in the reservoir level.

6.7 No serious negative hydrogeological impact of the reservoir on the surrounding area was identified. In general, the hydrogeological conditions should be considered favourable for the proposed reservoir. Slope stability considerations, possible effects of the reservoir on the dam and seepage through the dam foundations and abutments were not addressed in this study.

## 7. RECOMMENDATIONS

7.1 Due to the large area of the reservoir, further limited drilling and test pitting should be performed to provide more control on the local geology and hydraulic properties of the soil and bedrock, as well as on groundwater surface elevations. The slopes of the Pine Coulee should be test pitted to investigate the nature and thickness of the overlying silty clay.

7.2 The Stavely Buried Channel should be more accurately delineated and aquifer tested to determine its hydrogeological properties and those of the overlying deposits.

7.3 Detailed hydrogeological mapping of the few bedrock outcrops, which are below the reservoir F.S.L., should be conducted. If their presence could have an adverse impact on the proposed reservoir integrity, the outcrops should be excavated and/or clay lined.

7.4 A seepage drainage system should be constructed to collect and drain any surface or near surface water that seeps underneath the proposed east bank dyke.

7.5 The quality of water in wells and piezometers close to the reservoir should be monitored, both before and after the reservoir is filled, to accurately define any changes in groundwater chemistry.

Respectfully Submitted By:

PITEAU ENGINEERING LTD.

Bruce J Rutherford

B.J. Rutherford, E.I.T.

for Dr. T. L. Dabrowski, P. Eng.

TADEUSZ L. DABROWSKI

PERMIT TO PRACTICE
PITEAU ENGINEERING LTD.
Signature
Date oct. 25, 1985
PERMIT NUMBER: P 2607
The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

# 8. REFERENCES

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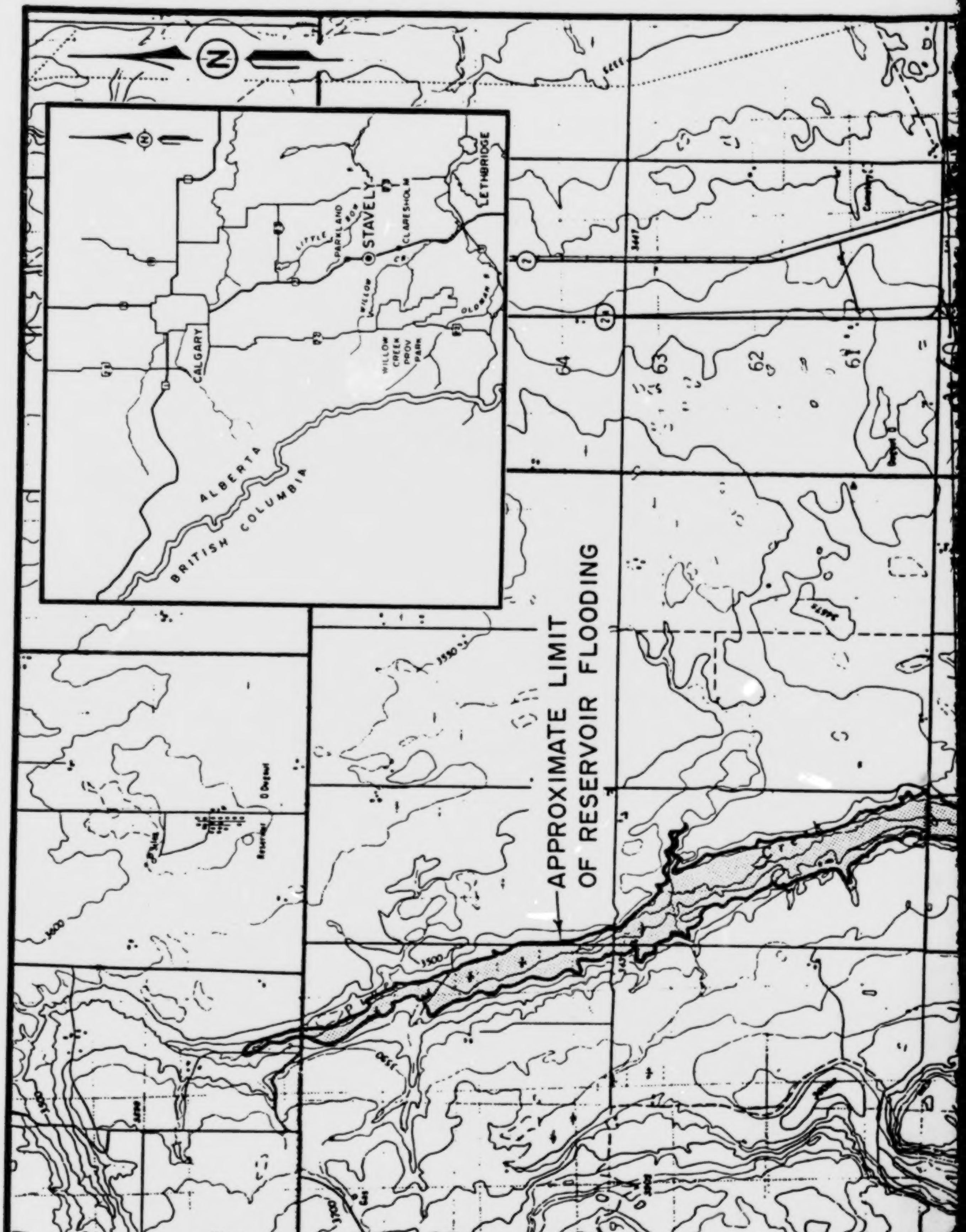
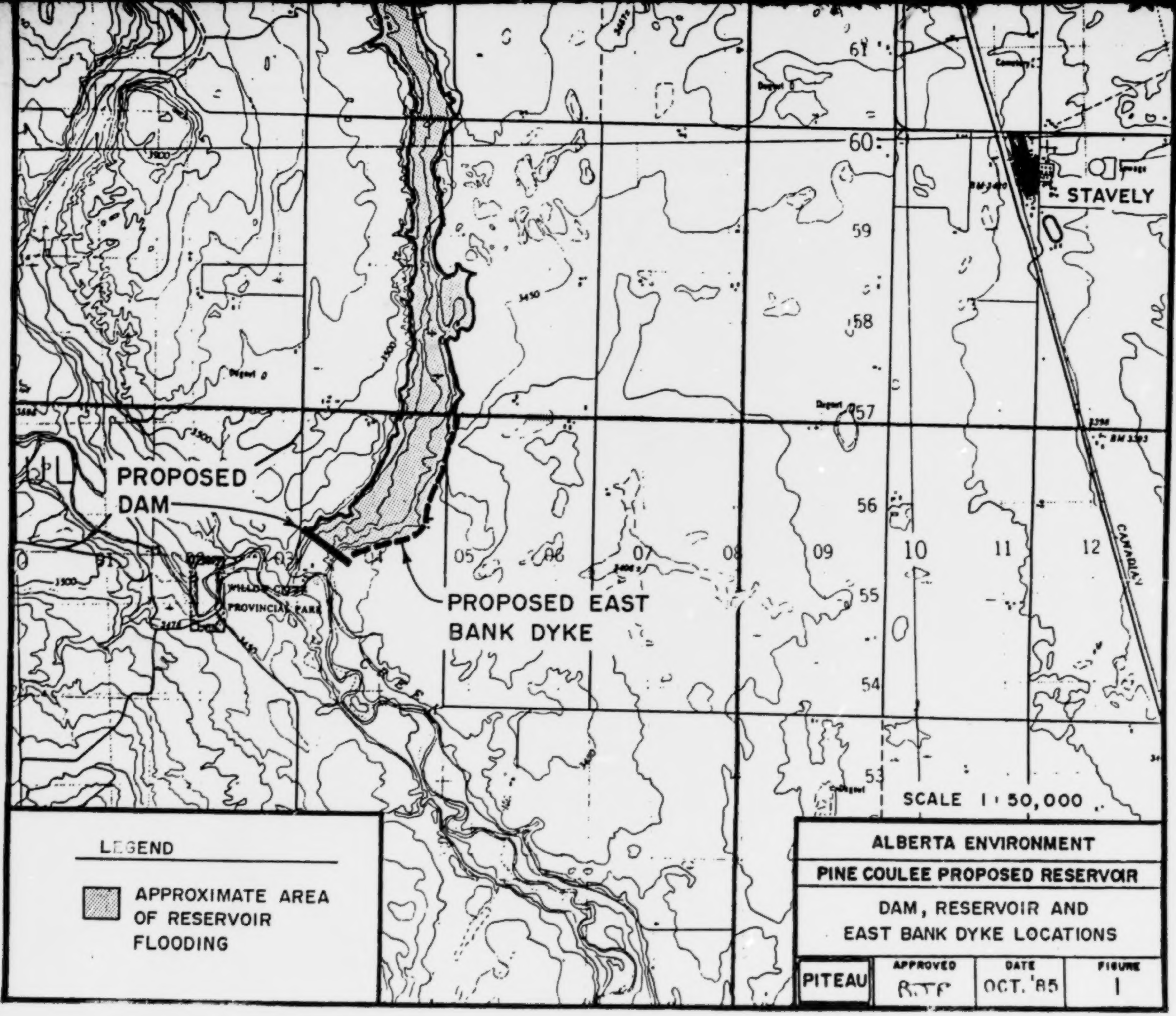
OZORAY, G.F. and LYTVIAK, A.T. 1974. Hydrogeology of the Gleichen Area, Alberta. Alberta Research Council Report 74-9, 16 pages plus map.

PAZDRO, Z. 1977. Hydrogeologia Ogolna. Wydraunicta Geologiczne Warszaua, 506 pages.


N
ALBERTA
BRITISH COLUMBIA
CALGARY
STAVELY
CLARESHOLM
LETHBRIDGE
LITTLE BOW
PARKLAND
WILLOW
WILLOW CREEK PROV PARK
OLDMAN R.
2
2A
64
63
62
61
3550
3500
3600
APPROXIMATE LIMIT OF RESERVOIR FLOODING



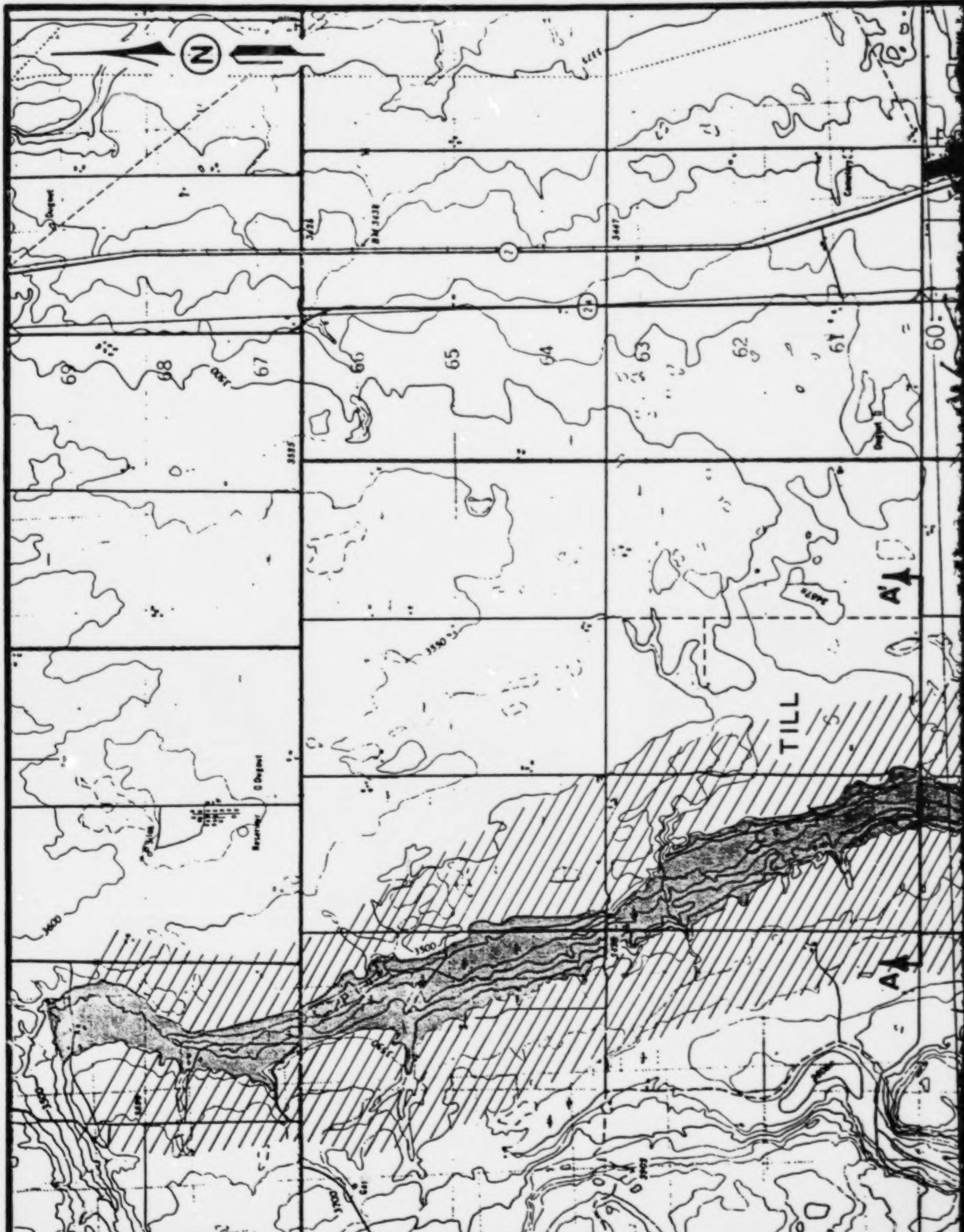
STAVELY
CANADIAN
PROPOSED DAM
PROPOSED EAST BANK DYKE
WILLOW CREEK PROVINCIAL PARK
CREEK
60
61
59
58
57
56
55
54
53
05
06
07
08
09
10
11
12
3500
3450
SCALE 1 : 50,000
LEGEND
APPROXIMATE AREA OF RESERVOIR FLOODING

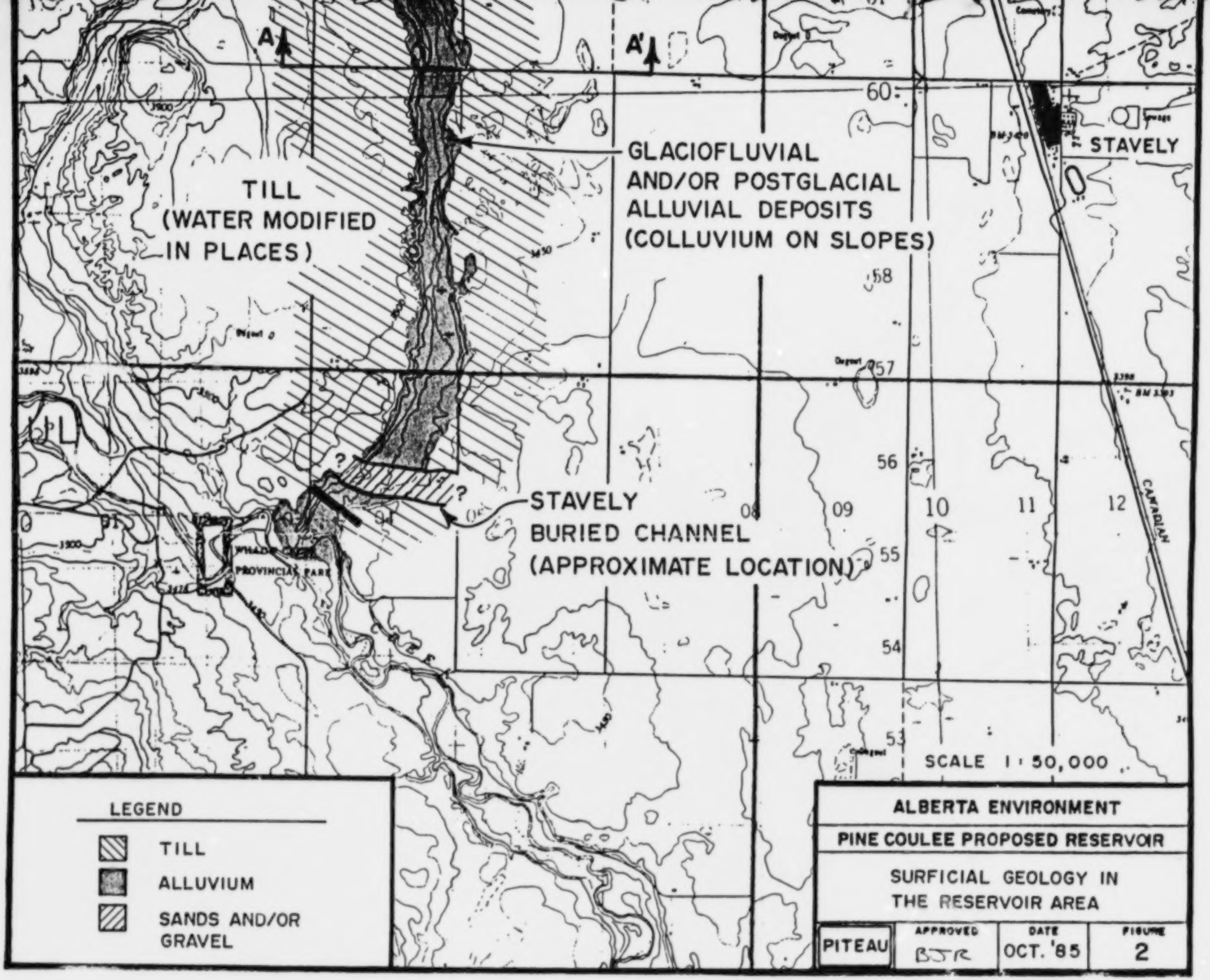
ALBERTA ENVIRONMENT

PINE COULEE PROPOSED RESERVOIR

DAM, RESERVOIR AND
EAST BANK DYKE LOCATIONS

| | APPROVED | DATE | FIGURE |
|---|---|---|---|
| PITEAU | R.T.F. | OCT. '85 | 1 |


N
TILL
A
A'
69
68
67
66
65
64
63
62
61
60
3400
3500
Dugout
Reservoir
Cemetery
BM 3438

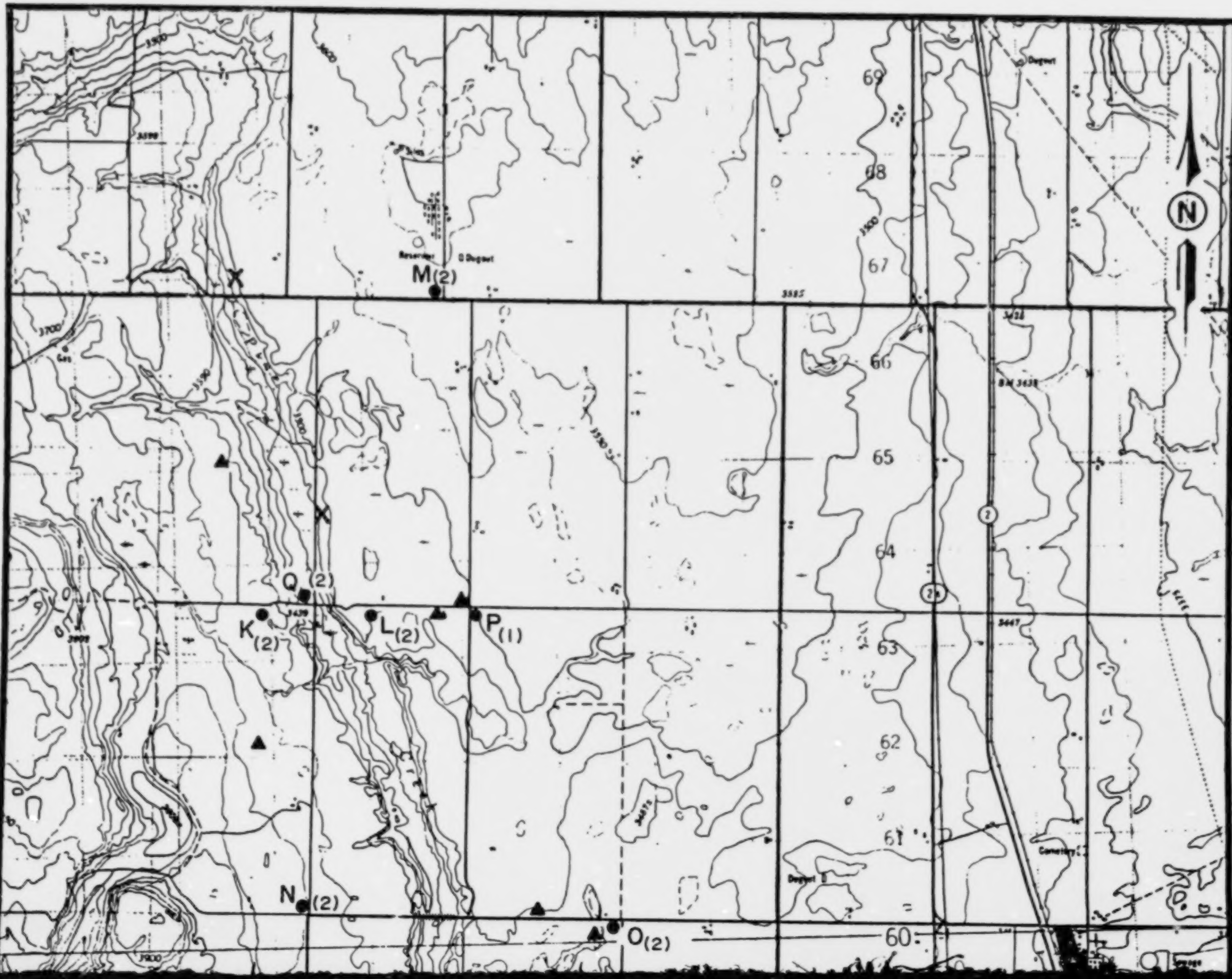

A
A'
60
TILL
(WATER MODIFIED
IN PLACES)
GLACIOFLUVIAL
AND/OR POSTGLACIAL
ALLUVIAL DEPOSITS
(COLLUVIUM ON SLOPES)
STAVELY
58
57
56
55
54
53
08
09
10
11
12
?
STAVELY
BURIED CHANNEL
(APPROXIMATE LOCATION)
PROVINCIAL PARK
CANADIAN
SCALE 1 : 50,000
LEGEND
▧ TILL
▩ ALLUVIUM
▨ SANDS AND/OR GRAVEL

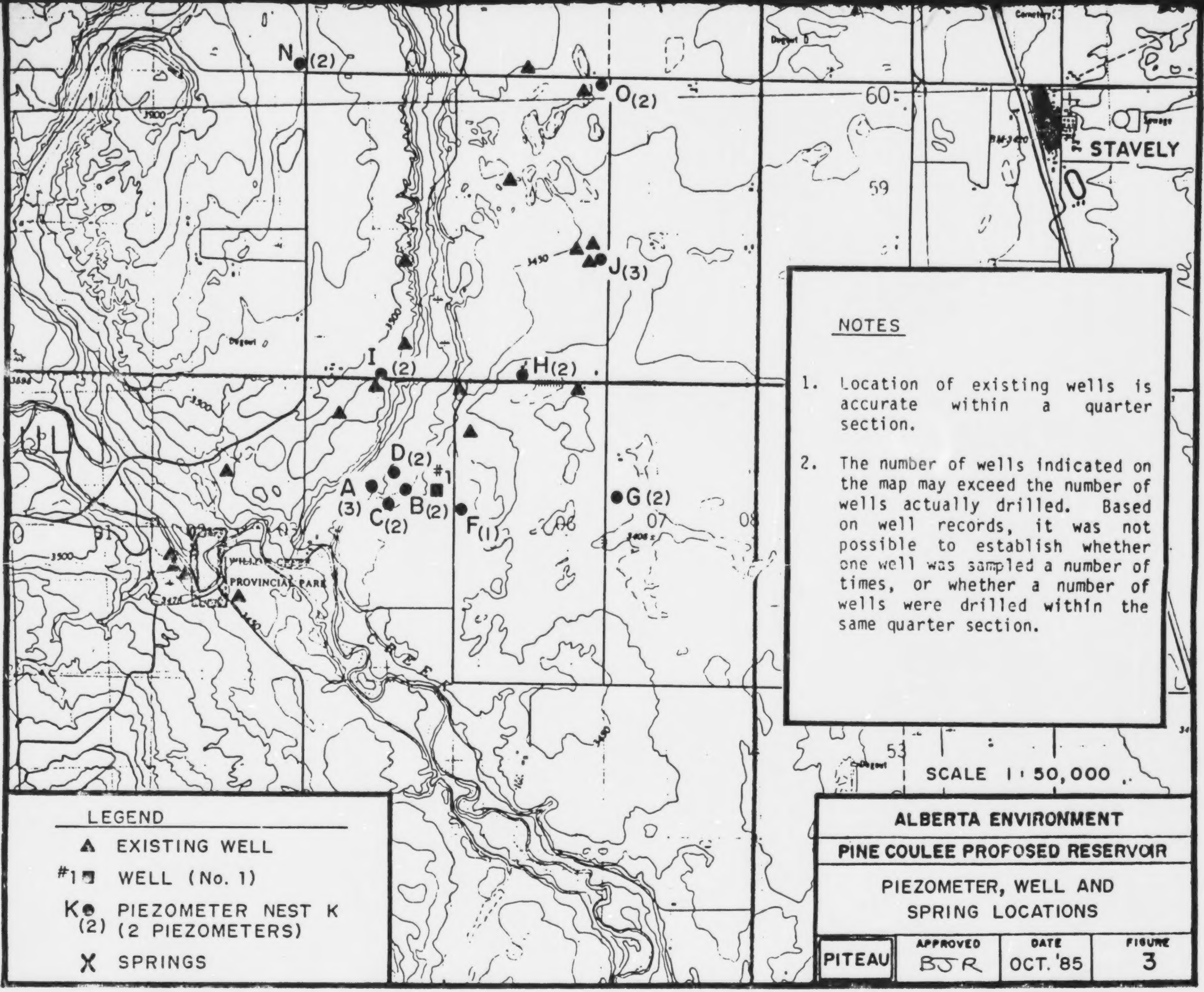
ALBERTA ENVIRONMENT

PINE COULEE PROPOSED RESERVOIR

SURFICIAL GEOLOGY IN
THE RESERVOIR AREA

| PITEAU | APPROVED | DATE | FIGURE |
|---|---|---|---|
| | BJR | OCT. '85 | 2 |


N
M(2)
Reservoir
Dugout
Dugout
Dugout
Cemetery
Gas
X
X
Q(2)
K(2)
L(2)
P(1)
N(2)
O(2)
2
2A
69
68
67
66
65
64
63
62
61
60
3585
3700
3600


N (2)
O (2)
60
59
STAVELY
J (3)
I (2)
H (2)
D (2)
#1
A (3)
B (2)
C (2)
F (1)
G (2)
06
07
08
53
WILLOW CREEK PROVINCIAL PARK
CREEK
LEGEND
▲ EXISTING WELL
#1 ■ WELL (No. 1)
K ● (2) PIEZOMETER NEST K (2 PIEZOMETERS)
X SPRINGS

NOTES

1. Location of existing wells is accurate within a quarter section.
2. The number of wells indicated on the map may exceed the number of wells actually drilled. Based on well records, it was not possible to establish whether one well was sampled a number of times, or whether a number of wells were drilled within the same quarter section.

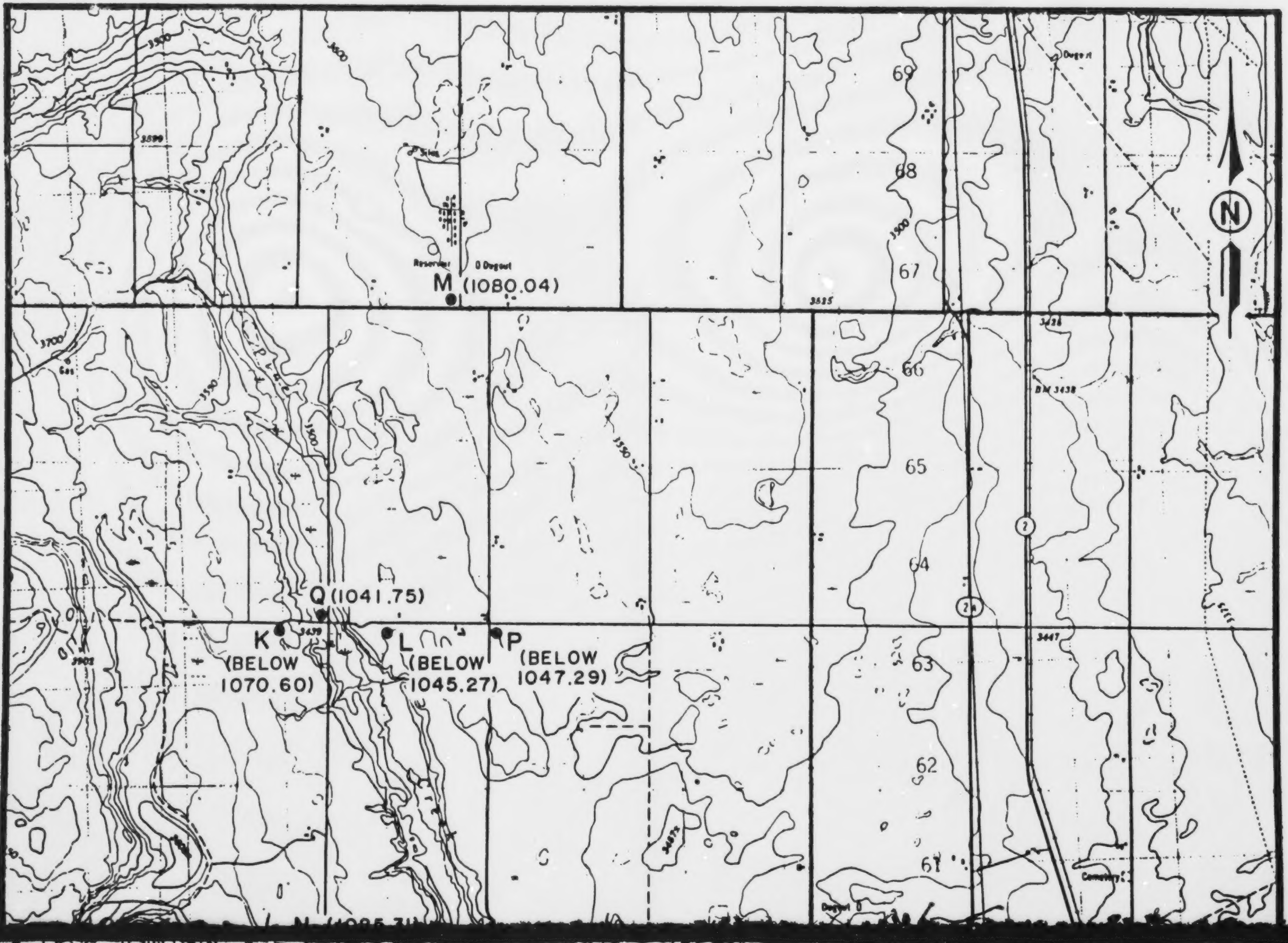
SCALE 1 : 50,000

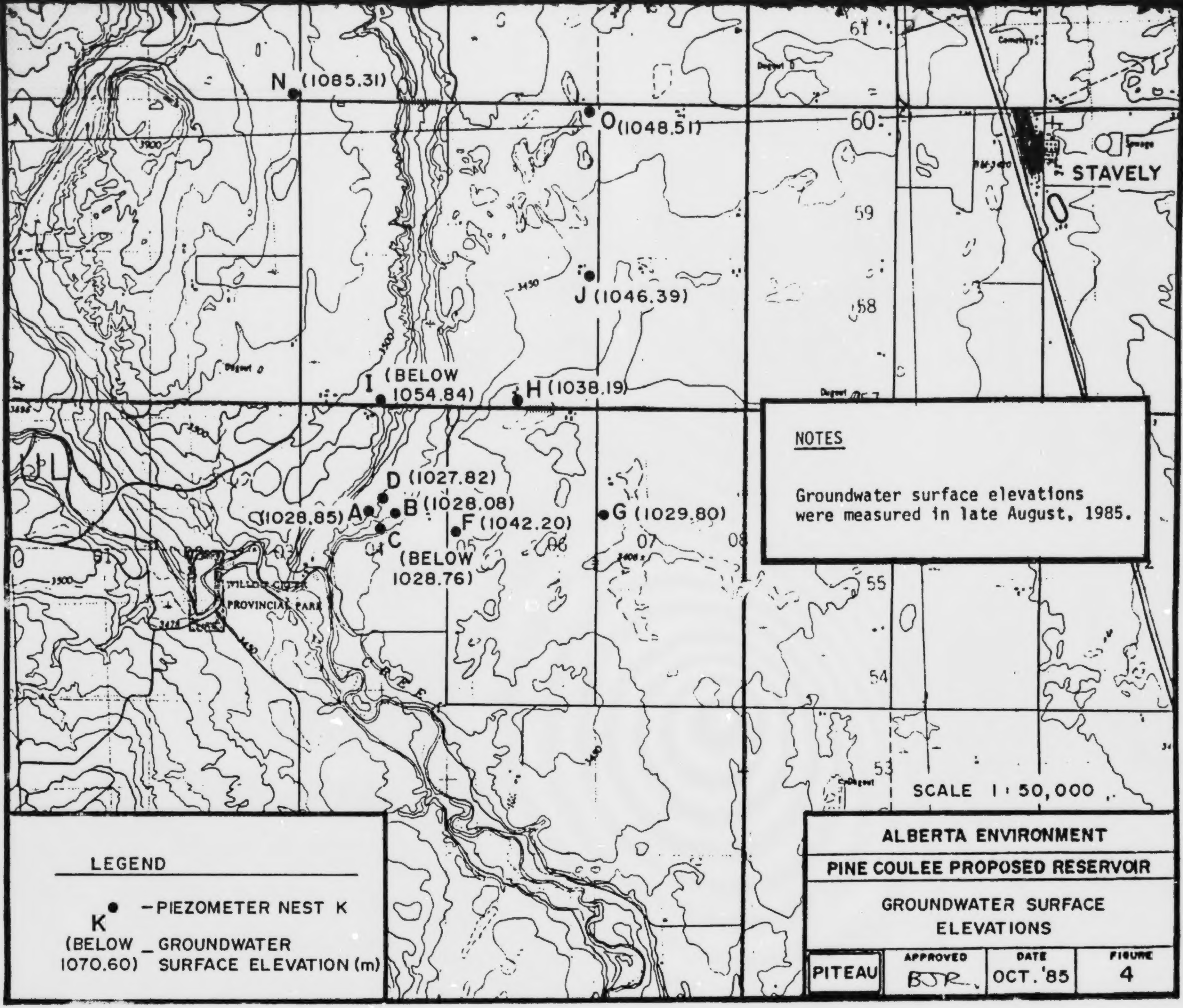
ALBERTA ENVIRONMENT

PINE COULEE PROFOSED RESERVOIR

PIEZOMETER, WELL AND
SPRING LOCATIONS

| PITEAU | APPROVED | DATE | FIGURE |
|---|---|---|---|
| | BJR | OCT. '85 | 3 |


N
69
68
67
66
65
64
63
62
61
2
2A
M (1080.04)
Reservoir
Dugout
Q (1041.75)
K (BELOW 1070.60)
L (BELOW 1045.27)
P (BELOW 1047.29)
3500
3525
3550
3700
BM 3438
3447
3436
Gas
Cemetery
Dugout
N (1085.7


N (1085.31)
O (1048.51)
60
STAVELY
59
J (1046.39)
58
I (BELOW 1054.84)
H (1038.19)
D (1027.82)
B (1028.08)
(1028.85) A
C (BELOW 1028.76)
F (1042.20)
G (1029.80)
55
54
53
WILLOW CREEK PROVINCIAL PARK
CREEK
3500
3450
3400
Dugout
Cemetery
Sewage

NOTES

Groundwater surface elevations were measured in late August, 1985.

SCALE 1 : 50,000

LEGEND

K ● – PIEZOMETER NEST K

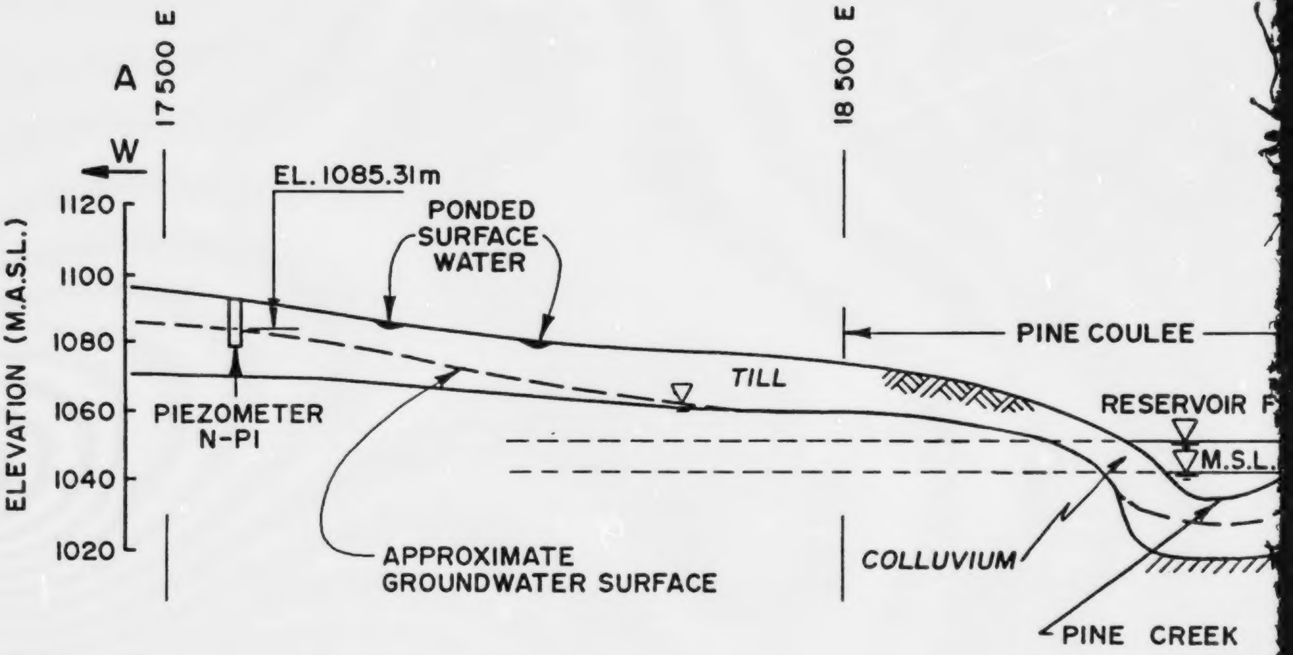
(BELOW 1070.60) – GROUNDWATER SURFACE ELEVATION (m)

ALBERTA ENVIRONMENT

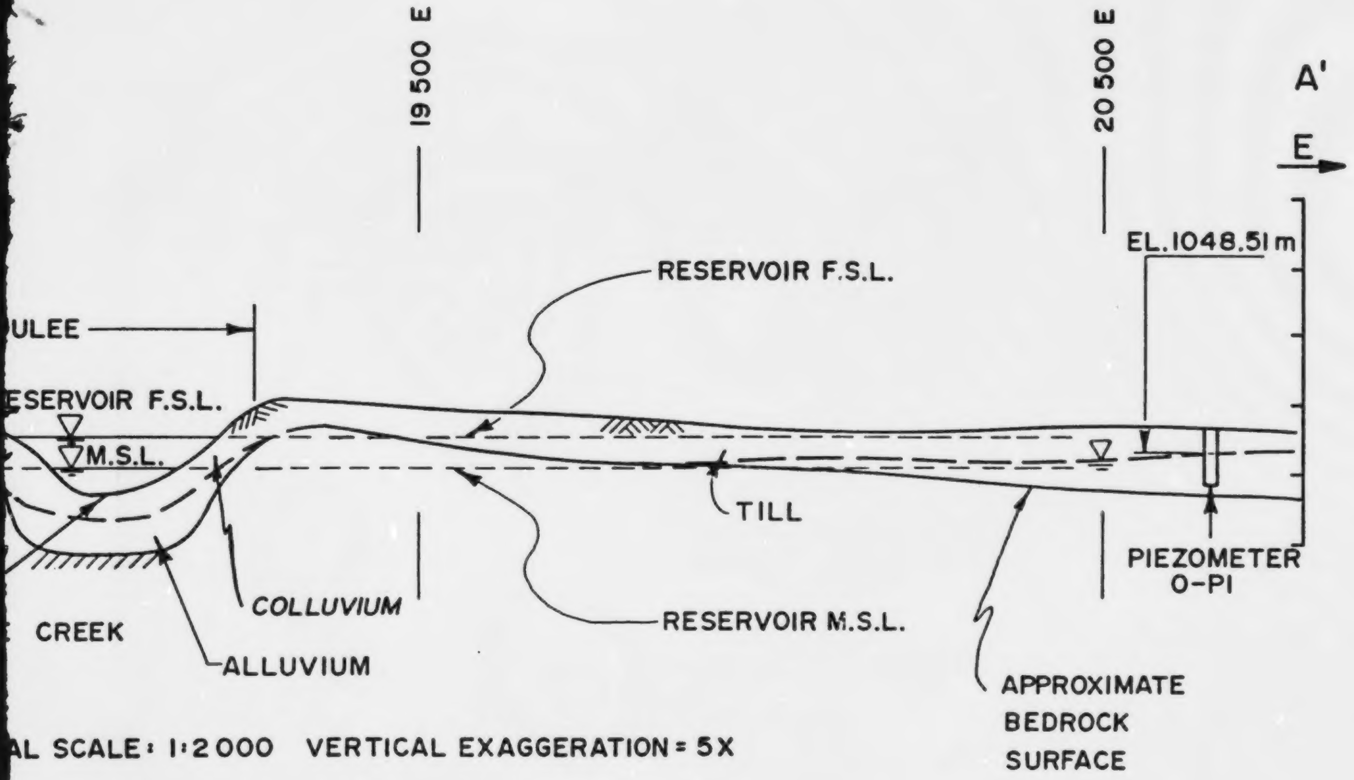
PINE COULEE PROPOSED RESERVOIR

GROUNDWATER SURFACE ELEVATIONS

| PITEAU | APPROVED | DATE | FIGURE |
|---|---|---|---|
| | BJR. | OCT. '85 | 4 |


A
W
17 500 E
18 500 E
ELEVATION (M.A.S.L.)
1120
1100
1080
1060
1040
1020
EL. 1085.31m
PONDED SURFACE WATER
PIEZOMETER N-P1
TILL
PINE COULEE
RESERVOIR F
M.S.L.
COLLUVIUM
APPROXIMATE GROUNDWATER SURFACE
PINE CREEK

HORIZONTAL SCALE : 1 : 10 000   VERTICAL SCALE :


19500 E
20500 E
A'
E
EL.1048.51m
RESERVOIR F.S.L.
ULEE
ESERVOIR F.S.L.
M.S.L.
TILL
PIEZOMETER
O-PI
COLLUVIUM
CREEK
RESERVOIR M.S.L.
ALLUVIUM
APPROXIMATE
BEDROCK
SURFACE

AL SCALE: 1:2000 VERTICAL EXAGGERATION = 5X

ALBERTA ENVIRONMENT

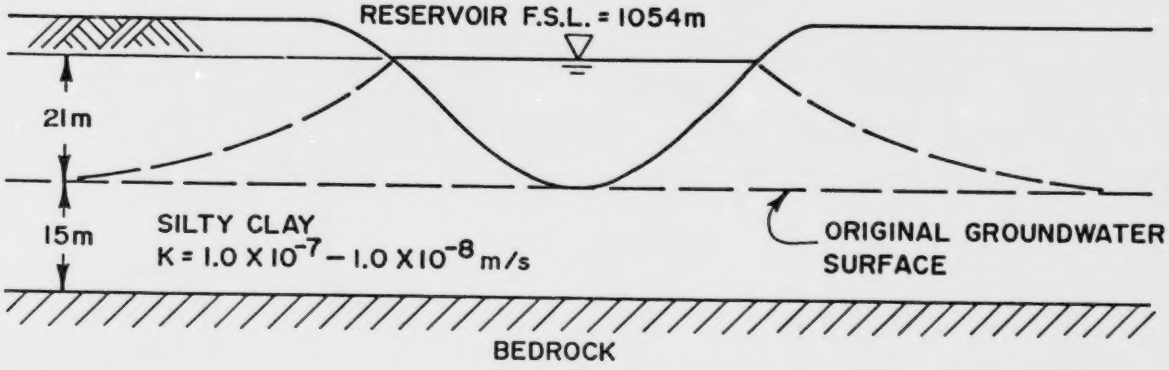
PINE COULEE PROPOSED RESERVOIR

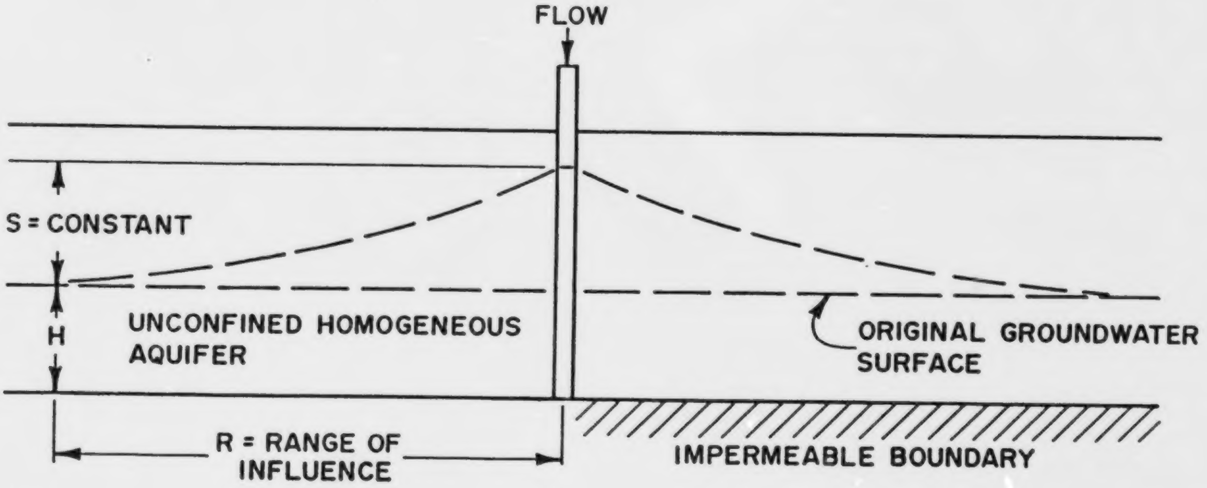
**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL CROSS-SECTION AA'
(5558450 N)

| | |
|---|---|
| BY: W.H. | DATE: OCT. '85 |
| APPROVED: BJR | FIGURE: 5 |

JOB NO. A85 2097


RESERVOIR
RESERVOIR F.S.L. = 1054m
21m
15m
SILTY CLAY
K = 1.0 X 10⁻⁷ – 1.0 X 10⁻⁸ m/s
ORIGINAL GROUNDWATER SURFACE
BEDROCK


RECHARGING WELL
(CONSTANT HEAD)
FLOW
S = CONSTANT
H
UNCONFINED HOMOGENEOUS AQUIFER
ORIGINAL GROUNDWATER SURFACE
R = RANGE OF INFLUENCE
IMPERMEABLE BOUNDARY

(EMPIRICAL FORMULA)

$$R = (S)(575)\sqrt{HK}$$

where: K = Hydraulic Conductivity (m/s)
H = Thickness of Aquifer (m)
S = Constant Head Height (m)

**ALBERTA ENVIRONMENT**

**PINE COULEE PROPOSED RESERVOIR**

**RANGE OF INFLUENCE**
**OF RESERVOIR**
**USING RECHARGING WELL ANALOGY**

| PITEAU | APPROVED | DATE | FIGURE |
|---|---|---|---|
|  | BJK | SEP/85 | 6 |

# SITE SURVEY RESULTS

D. A. Watt Consulting Group Ltd.
CONSULTING ENGINEERS AND LAND SURVEYORS

David A. Watt, P. Eng
Tom C. Medlicott, A.L.S.
Martin A. Broks, P. Eng

#101, 112 - 28th Street S.E
Calgary, Alberta T2A 6J9
Telephone (403) 273-9001

7401

September 12, 1985.

Alberta Environment,
3rd Floor, 4920 - 51st Street,
Red Deer, Alberta.
T4N 6K8

ATTENTION: Mr. D. Hubbard.

Dear Sir:

Re: Willow Creek -
Piezometer Locations and Elevations.

Please find enclosed our original Field Notes for the above noted project. Also enclosed is our summary of co-ordinates and elevations, compiled on the attached Table.

Please contact the writer should you require any further information.

Yours truly,

Tom Medlicott, A.L.S.,
Survey Manager.

TM/myw
Enc.

c.c. Piteau Engineering
ATTN: Mr. B. Rutherford

# WILLOW CREEK PIEZOMETERS

LISING OF HORIZONTAL "SEA LEVEL" CO-ORDINATES AND GEODETIC ELEVATIONS.

| PIEZOMETER | CO-ORDINATES | | ELEVATIONS | | |
|---|---|---|---|---|---|
| NAME | NORTHING | EASTING | CASING (N.RIM) | PLASTIC PIPE ELEVATION | GROUND ELEVATION |
| A(P1) | 5554039.517 | 18310.419 | 1034.147 | 1034.027 | 1033.683 |
| A(P2) | 5554039.896 | 18312.464 | 1034.150 | 1034.024 | 1033.647 |
| A(P3) | 5554037.927 | 18312.283 | 1034.196 | 1034.124 | 1033.692 |
| B(P1) | 5554013.059 | 18666.674 | 1034.428 | 1034.293 | 1033.813 |
| B(P2) | 5554014.462 | 18666.267 | 1034.373 | 1034.268 | 1033.783 |
| C(P1) | 5553856.670 | 18515.985 | 1034.443 | 1034.296 | 1033.827 |
| C(P2) | 5553856.446 | 18513.254 | 1034.390 | 1034.245 | 1033.842 |
| D(P1) | 5554184.043 | 18520.420 | 1034.100 | 1033.957 | 1033.629 |
| D(P2) | 5554183.645 | 18519.109 | 1034.141 | 1033.987 | 1033.644 |
| F | 5553897.237 | 19249.228 | 1046.343 | 1046.231 | 1045.809 |
| G(P1) | 5554084.888 | 20867.817 | 1042.630 | 1042.549 | 1042.074 |
| G(P2) | 5554083.292 | 20867.632 | 1042.634 | 1042.456 | 1042.064 |
| H(P1) | 5555205.480 | 19934.045 | 1042.451 | 1042.328 | 1041.932 |
| H(P2) | 5555205.578 | 19932.298 | 1042.414 | 1042.269 | 1041.952 |
| I(P1) | 5555199.615 | 18417.848 | 1063.463 | 1063.371 | 1062.971 |
| I(P2) | 5555199.612 | 18416.707 | 1063.729 | 1063.627 | 1063.071 |
| J(P1) | 5556629.493 | 20840.020 | 1051.252 | 1051.137 | 1050.700 |
| J(P2) | 5556630.881 | 20840.175 | 1051.238 | 1051.063 | 1050.770 |
| J(P3) | 5556631.928 | 20840.215 | 1051.339 | 1051.221 | 1050.760 |
| K(P1) | 5561658.027 | 17156.446 | 1085.432 | 1085.327 | 1084.922 |
| K(P2) | 5561658.177 | 17157.883 | 1085.412 | 1085.234 | 1084.932 |
| L(P1) | 5561655.578 | 18161.047 | 1060.427 | 1060.202 | 1059.918 |
| L(P2) | 5561655.541 | 18162.480 | 1060.345 | 1060.269 | 1059.818 |
| M(P2)WEST | 5564892.874 | 18845.697 | 1093.191 | 1093.069 | 1092.697 |
| M(P1)EAST | 5564892.896 | 18847.365 | 1093.189 | 1093.095 | 1092.687 |
| N(P1) | 5558466.644 | 17575.896 | 1095.943 | 1095.833 | 1095.375 |
| N(P2) | 5558468.244 | 17575.916 | 1095.924 | 1095.803 | 1095.364 |
| O(P1) | 5558428.552 | 20655.704 | 1055.241 | 1055.162 | 1054.680 |
| O(P2) | 5558428.604 | 20656.910 | 1055.297 | 1055.008 | 1054.682 |
| P | 5561649.623 | 19208.156 | 1065.252 | 1065.122 | 1064.692 |
| Q(P1) | 5561698.632 | 17569.922 | 1044.320 | 1044.175 | 1043.790 |
| Q(P2) | 5561700.820 | 17569.856 | 1044.247 | 1044.127 | 1043.717 |

Prepared by:
D. A. WATT CONSULTING GROUP LTD.

September 12, 1985

# BOREHOLE LOGS AND PIEZOMETER COMPLETION DETAILS

| LEGEND | | MODIFIED U.S.C. CLASSIFICATION |
|---|---|---|
| ≋ | ORGANIC TOPSOIL, LOW PLASTICITY | OL |
| ▥ | SILT, LOW PLASTICITY | ML |
| ▨ | CLAY, LOW PLASTICITY | CL |
| ▨ | CLAY, INTERMEDIATE PLASTICITY | CI |
| ▨ | CLAY, HIGH PLASTICITY | CH |
| ░ | SAND, WITH SILT ON CLAY | SM, SC |
| ▓ | GRAVEL, WITH CLAY | GC |
| ▧ | SHALE | |
| ▤ | SANDSTONE | |

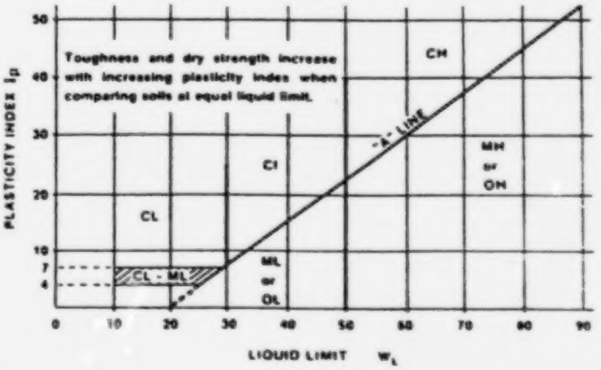
# SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

| MAJOR DIVISION | | | GROUP SYMBOL | GRAPHIC SYMBOL | COLOR CODE | TYPICAL DESCRIPTION | LABORATORY CLASSIFICATION CRITERIA | |
|---|---|---|---|---|---|---|---|---|
| HIGHLY ORGANIC SOILS | | | PT | ▤ | ORANGE | PEAT AND OTHER HIGHLY ORGANIC SOILS | STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE | |
| COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE) | GRAVELS MORE THAN HALF COARSE FRACTION LARGER THAN NO. 4 SIEVE SIZE | CLEAN GRAVELS | GW | ░ | RED | WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, < 5% FINES | $C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3 | |
| | | | GP | ░ | RED | POORLY-GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, < 5% FINES | NOT MEETING ALL ABOVE REQUIREMENTS | |
| | | DIRTY GRAVELS | GM | ░ | YELLOW | SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES > 12% FINES | ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$ | |
| | | | GC | ▨ | YELLOW | CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES > 12% FINES | ATTERBERG LIMITS ABOVE "A" LINE, $I_p > 7$ | |
| | SANDS MORE THAN HALF COARSE FRACTION SMALLER THAN NO. 4 SIEVE SIZE | CLEAN SANDS | SW | ░ | RED | WELL-GRADED SANDS, GRAVELLY SANDS, < 5% FINES | $C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3 | |
| | | | SP | ░ | RED | POORLY-GRADED SANDS, OR GRAVELLY SANDS, < 5% FINES | NOT MEETING ALL ABOVE REQUIREMENTS | |
| | | DIRTY SANDS | SM | ▥ | YELLOW | SILTY SANDS, SAND-SILT MIXTURES > 12% FINES | ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$ | |
| | | | SC | ▨ | YELLOW | CLAYEY SANDS, SAND-CLAY MIXTURES > 12% FINES | ATTERBERG LIMITS ABOVE "A" LINE OR $I_p > 7$ | |
| FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE SIZE) | SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT | | ML | ▥ | GREEN | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY | $W_L < 50$ | SEE CHART BELOW |
| | | | MH | ▥ | BLUE | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS | $W_L > 50$ | |
| | CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT | | CL | ▨ | GREEN | INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS | $W_L < 30$ | |
| | | | CI | ▨ | GREEN-BLUE | INORGANIC CLAYS OF MEDIUM PLASTICITY SILTY CLAYS | $W_L > 30,\ < 50$ | |
| | | | CH | ▨ | BLUE | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS | $W_L > 50$ | |
| | ORGANIC SILTS & ORGANIC CLAYS BELOW "A" LINE ON PLASTICITY CHART | | OL | ▥ | GREEN | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY | $W_L < 50$ | |
| | | | OH | ▨ | BLUE | ORGANIC CLAYS OF HIGH PLASTICITY | $W_L > 50$ | |

1. All sieve sizes mentioned on this chart are U.S. Standard, ASTM E11.
2. Boundary classifications possessing characteristics of two groups are given combined group symbols eg GW-GC is a well-graded gravel-sand mixture with clay binder between 5% and 12%.
3. Soil fractions and limiting textural boundaries are in accordance with the Unified Soil Classification System, except that an inorganic clay of medium plasticity (CI) is recognized
4. The following adjectives may be employed to define percentage ranges by weight of minor components:

| | |
|---|---|
| and | 50 - 36% |
| some | 35 - 21% |
| little | 20 - 11% |
| trace | 10 - 1% |

PLASTICITY CHART



**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 3

| | | |
|---|---|---|
| Contract No. ABS-2097 | Compiled By B.J. Rutherford | Boring Date August 8, 1985 |
| Boring No. A-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5554039.517 m | Easting 18310,419 m | Elevation 1033.683 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

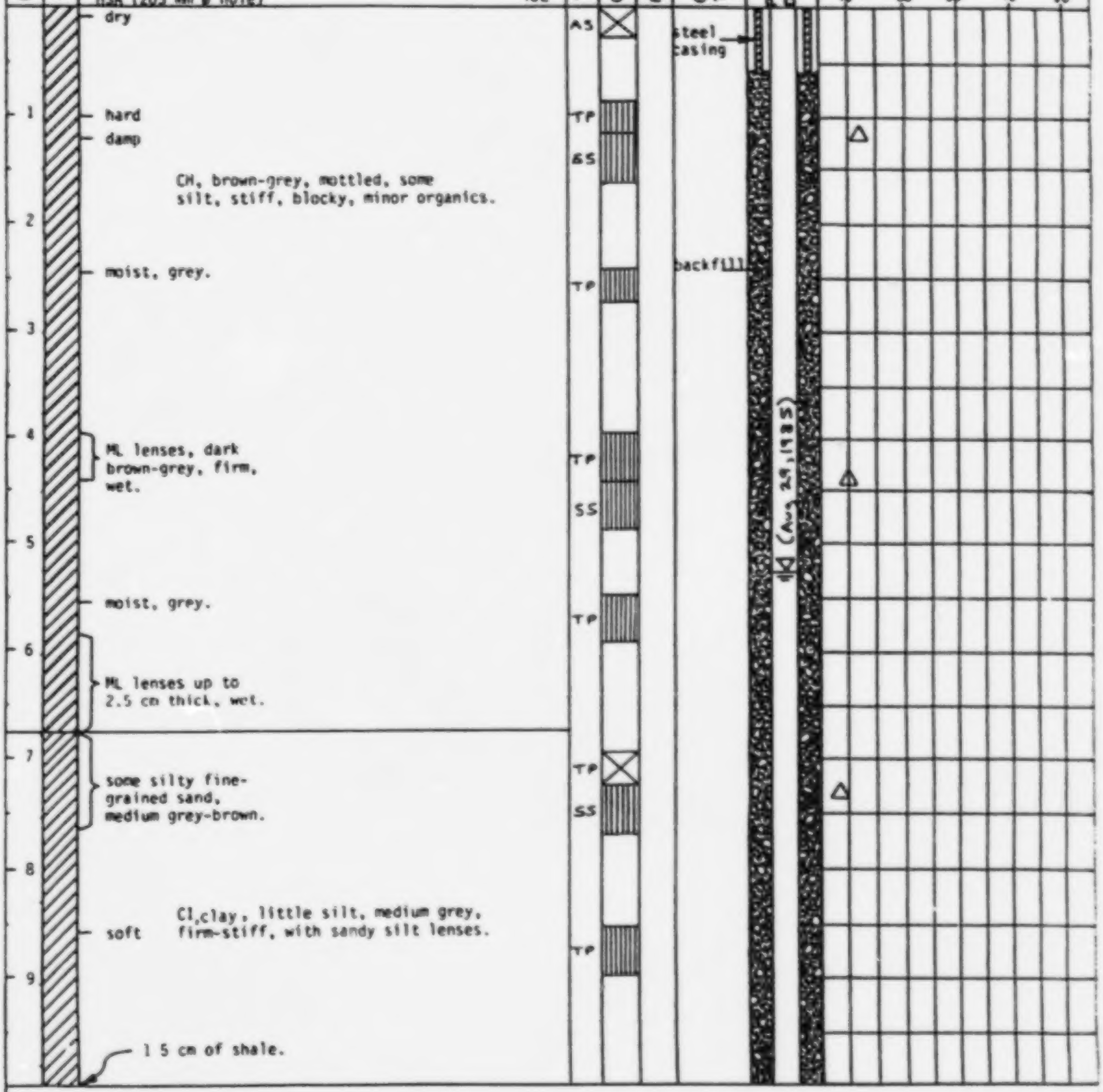
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM ⊙ LIQUID LIM

Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | ICE | SAMPLES: Type, Condition, Number, OTHER TESTS | PIEZOMETER DETAILS

HSA (203 mm Ø hole)



- dry
- hard
- damp

CH, brown-grey, mottled, some silt, stiff, blocky, minor organics.

- moist, grey.

ML lenses, dark brown-grey, firm, wet.

- moist, grey.

ML lenses up to 2.5 cm thick, wet.

some silty fine-grained sand, medium grey-brown.

- soft

CI, clay, little silt, medium grey, firm-stiff, with sandy silt lenses.

1 5 cm of shale.

NOTES:

JOB NO. 2097 BORING NO. A-P1

**PITEAU ENGINEERING LTD.**
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## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 3

Contract No. ABS-2097
Boring No. A-P1
Northing 5554039.517 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18310,419 m
Boring Date August 8, 1985
Contractor Allkind Drilling
Elevation 1033,683 m (Ground)

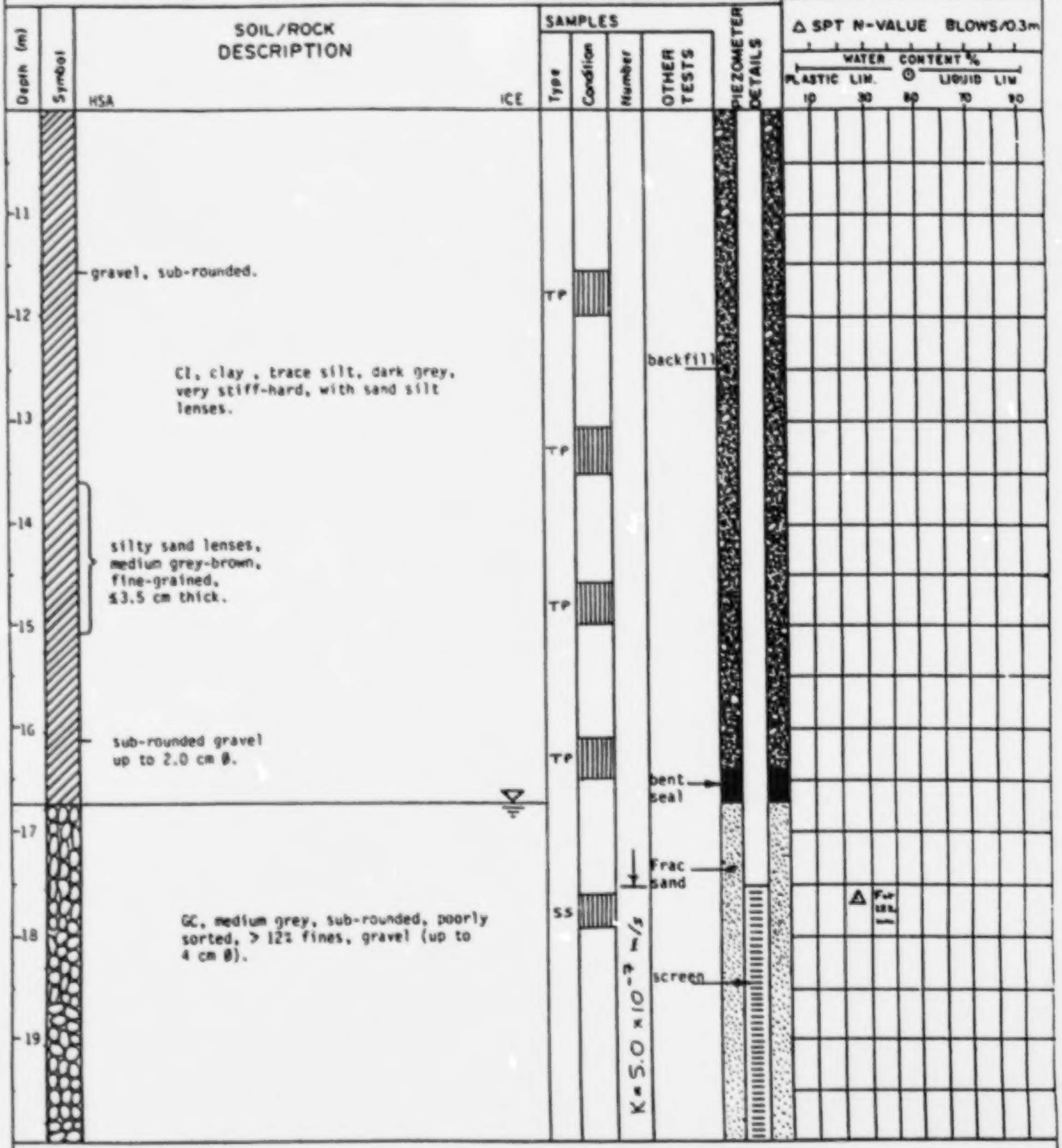
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²
- △ SPT N-VALUE BLOWS/0.3m


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM
10
30
50
70
90
11
12
13
14
15
16
17
18
19
TP
TP
TP
TP
SS
backfill
bent. seal
Frac sand
screen
$K = 5.0 \times 10^{-7}$ m/s

gravel, sub-rounded.

CI, clay, trace silt, dark grey, very stiff-hard, with sand silt lenses.

silty sand lenses, medium grey-brown, fine-grained, ≤3.5 cm thick.

sub-rounded gravel up to 2.0 cm Ø.

GC, medium grey, sub-rounded, poorly sorted, > 12% fines, gravel (up to 4 cm Ø).

NOTES:

JOB NO. 2097 BORING NO. A-P1

**PITEAU ENGINEERING LTD.**
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# OFFICE REPORT ON SITE INVESTIGATION

Sheet 3 of 3

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 8, 1985 |
| Boring No. A-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5554039.517 m | Easting 18310.419 m | Elevation 1033,683 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION

- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²

△ SPT N-VALUE BLOWS/0.3m

WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM
10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION (HSA … ICE) | Samples: Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS | Test Information |
|---|---|---|---|---|---|---|---|---|
| | | GC, as above. | | | K | Frac sand<br>screen | | |
| | | SSt., medium grey, medium-fine grained, very hard. Possibly bedrock. | SS | ▥ | | | | △ For 50 |
| 21 | | | | | | | | |
| | | End of Hole @ 20.57 m.<br>(Drill unable to penetrate) | | | | | | |

NOTES:

JOB NO. 2097 BORING NO. A-P1

**PITEAU ENGINEERING LTD.**
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## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

Contract No. A85-2097
Boring No. A-P2
Northing 5554039.896 m.
Compiled By R.J. Rutherford.
Location Pine Coulee
Easting 18312.464 m
Boring Date August 9, 1985
Contractor Allkind Drilling
Elevation 1033.647 m (Ground)

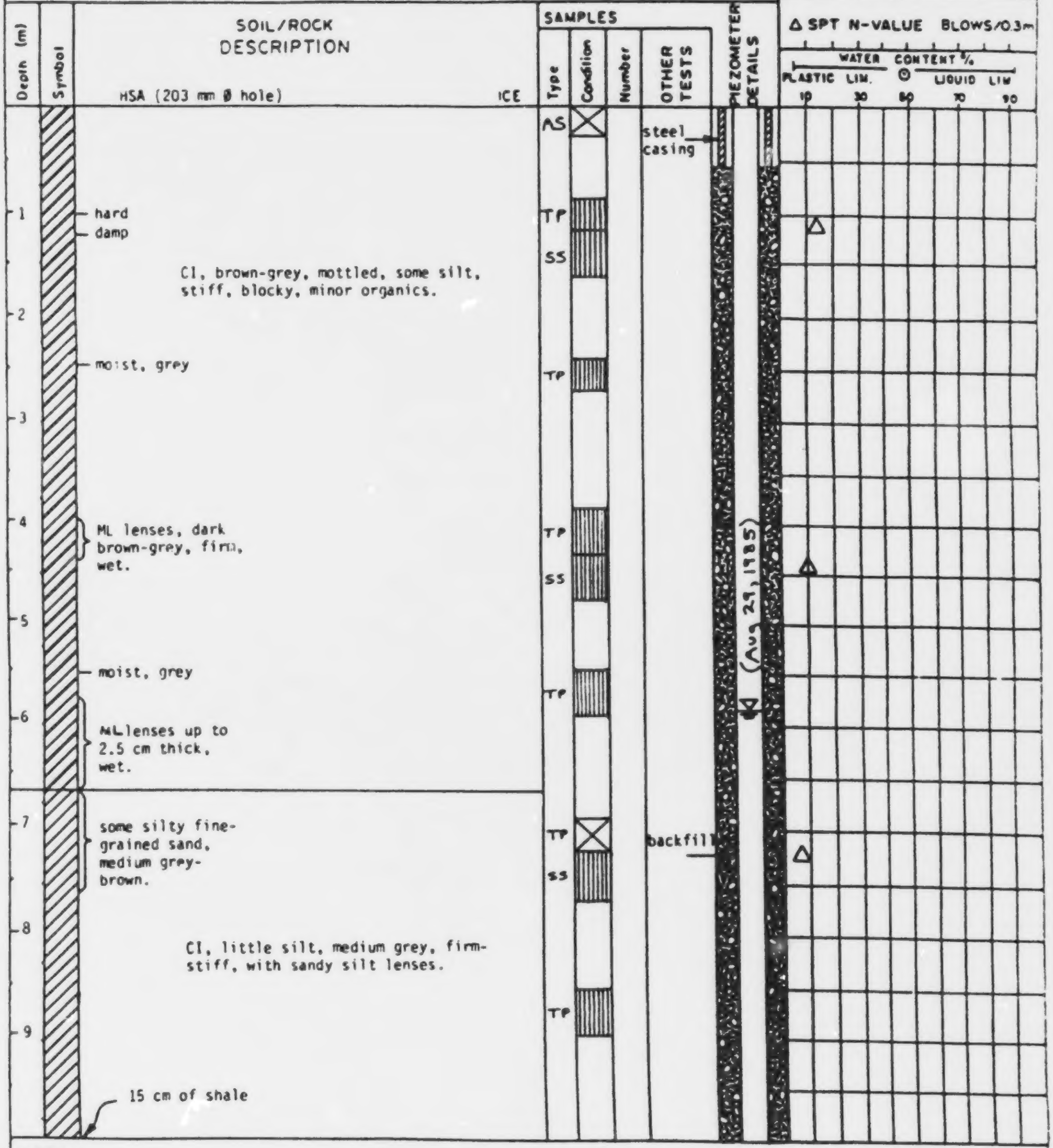
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA (203 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
Δ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
SS
TP
TP
SS
TP
TP
SS
TP
steel casing
backfill
(Aug 29, 1985)

- hard
- damp

CI, brown-grey, mottled, some silt, stiff, blocky, minor organics.

- moist, grey

ML lenses, dark brown-grey, firm, wet.

- moist, grey

ML lenses up to 2.5 cm thick, wet.

some silty fine-grained sand, medium grey-brown.

CI, little silt, medium grey, firm-stiff, with sandy silt lenses.

15 cm of shale

NOTES:

JOB NO. 2097 BORING NO. A-P2

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# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

Contract No. A85-2097
Boring No. A-P2
Northing 5554039.896 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18312,464 m
Boring Date August 9, 1985
Contractor Allkind Drilling
Elevation 1033,647 m (Ground)

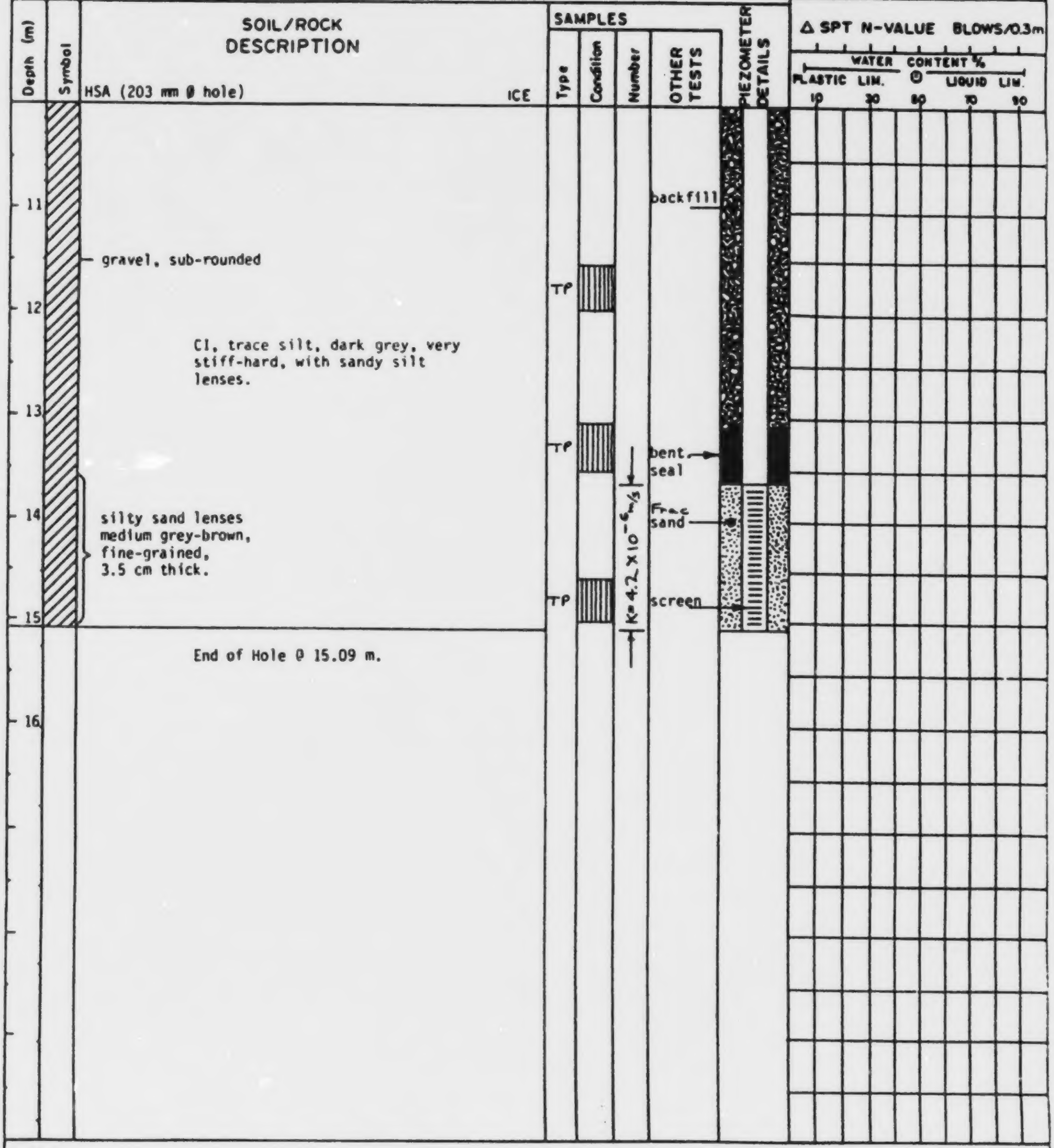
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA (203 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
11
12
13
14
15
16
TP
TP
TP
K= 4.2 x 10⁻⁶ m/s
backfill
bent. seal
Frac sand
screen

gravel, sub-rounded

CI, trace silt, dark grey, very stiff-hard, with sandy silt lenses.

silty sand lenses medium grey-brown, fine-grained, 3.5 cm thick.

End of Hole @ 15.09 m.

NOTES:

JOB NO. 2097 BORING NO. A-P2

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## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 11, 1985 |
| Boring No. A-P3 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5554037.927 m | Easting 18312.283 m | Elevation 1033.697 m (Ground) |

**SAMPLE TYPES**

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

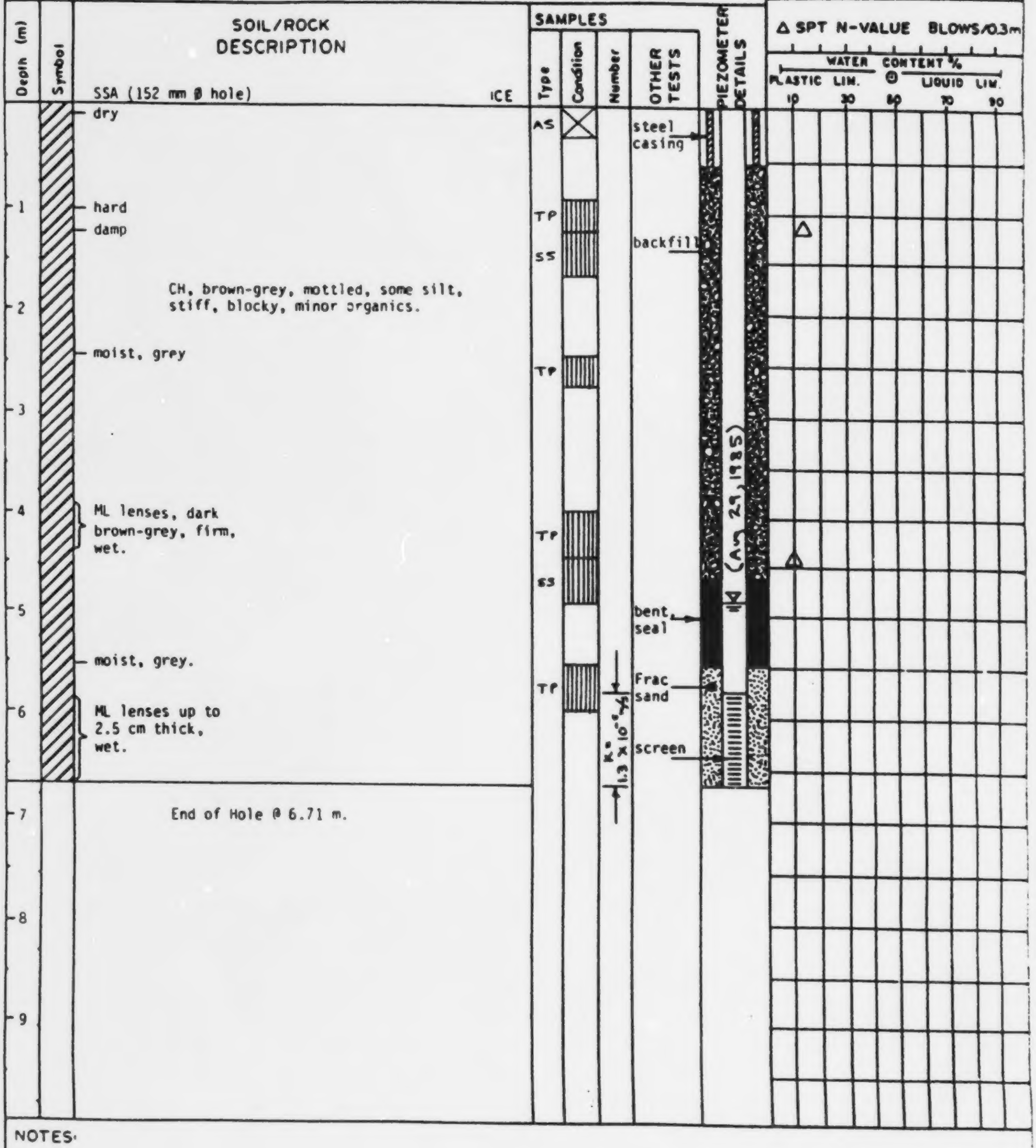
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

**SAMPLE CONDITION**

☒ Disturbed
▥ Fair
▨ Good
■ Lost

**TEST INFORMATION**

● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
SS
TP
TP
SS
TP
steel casing
backfill
bent. seal
Frac sand
screen
(Aug 29, 1985)
$K = 1.3 \times 10^{-6}$ m/s

- dry
- hard
- damp

CH, brown-grey, mottled, some silt, stiff, blocky, minor organics.

- moist, grey

ML lenses, dark brown-grey, firm, wet.

- moist, grey.

ML lenses up to 2.5 cm thick, wet.

End of Hole @ 6.71 m.

NOTES:

JOB NO. 2097 BORING NO. A-P3

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# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 3

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By R.J. Rutherford | Boring Date August 9 & 10, 1985 |
| Boring No. B - P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5554013.059 m | Easting 18666,674 m | Elevation 1033.813 m (Ground) |

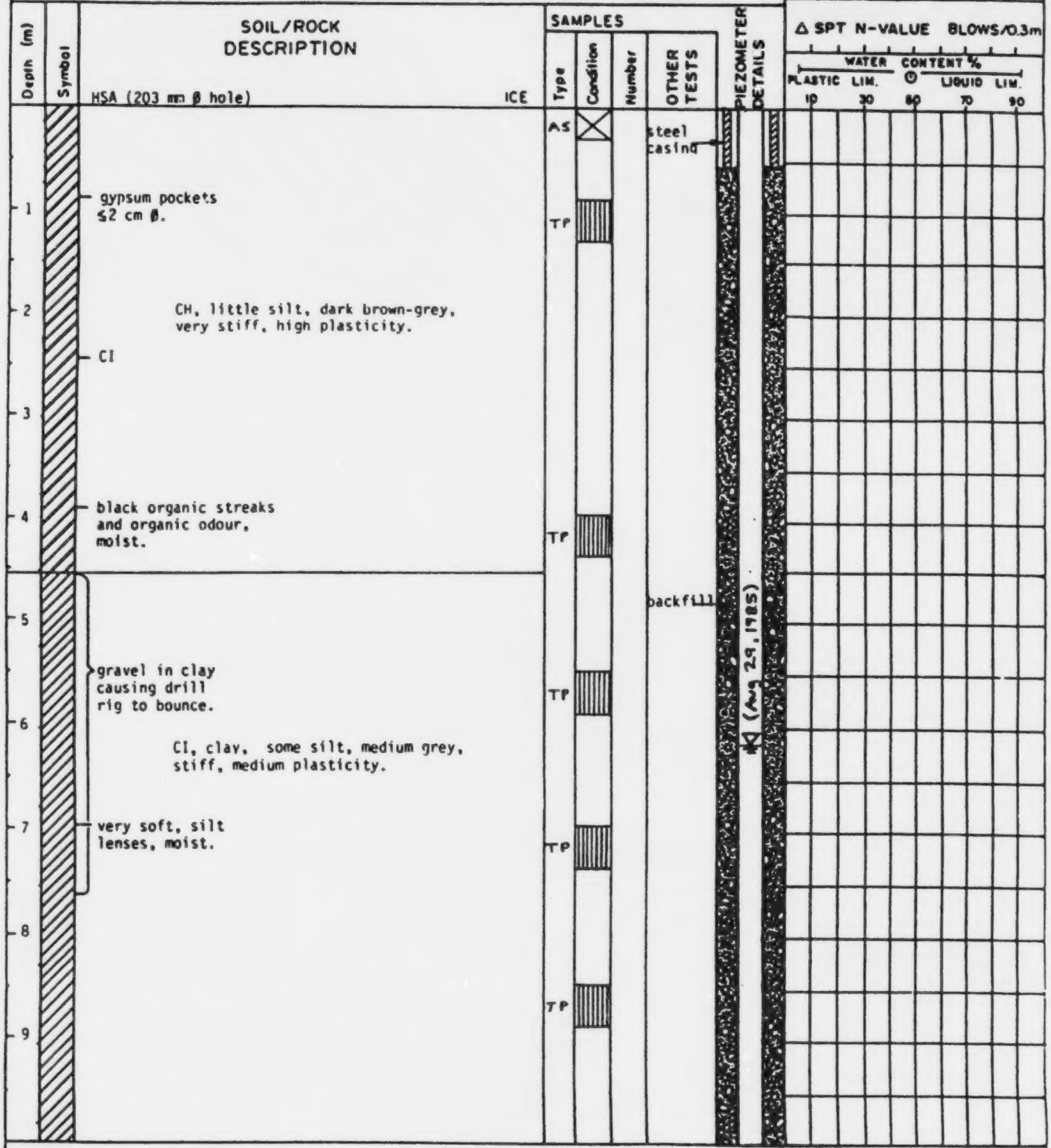
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA (203 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
TP
TP
TP
steel casing
backfill
(Aug 29, 1985)

gypsum pockets ≤2 cm Ø.

CH, little silt, dark brown-grey, very stiff, high plasticity.

CI

black organic streaks and organic odour, moist.

gravel in clay causing drill rig to bounce.

CI, clay, some silt, medium grey, stiff, medium plasticity.

very soft, silt lenses, moist.

NOTES:

JOB NO. 2097 BORING NO. B-P1.

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 3

Contract No. A85-2097
Boring No. B-P1
Northing 5554013.059 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18666.674 m
Boring Date August 9 & 10, 1985
Contractor Allkind Drilling
Elevation 1033.813 m (Ground)

**SAMPLE TYPES**

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

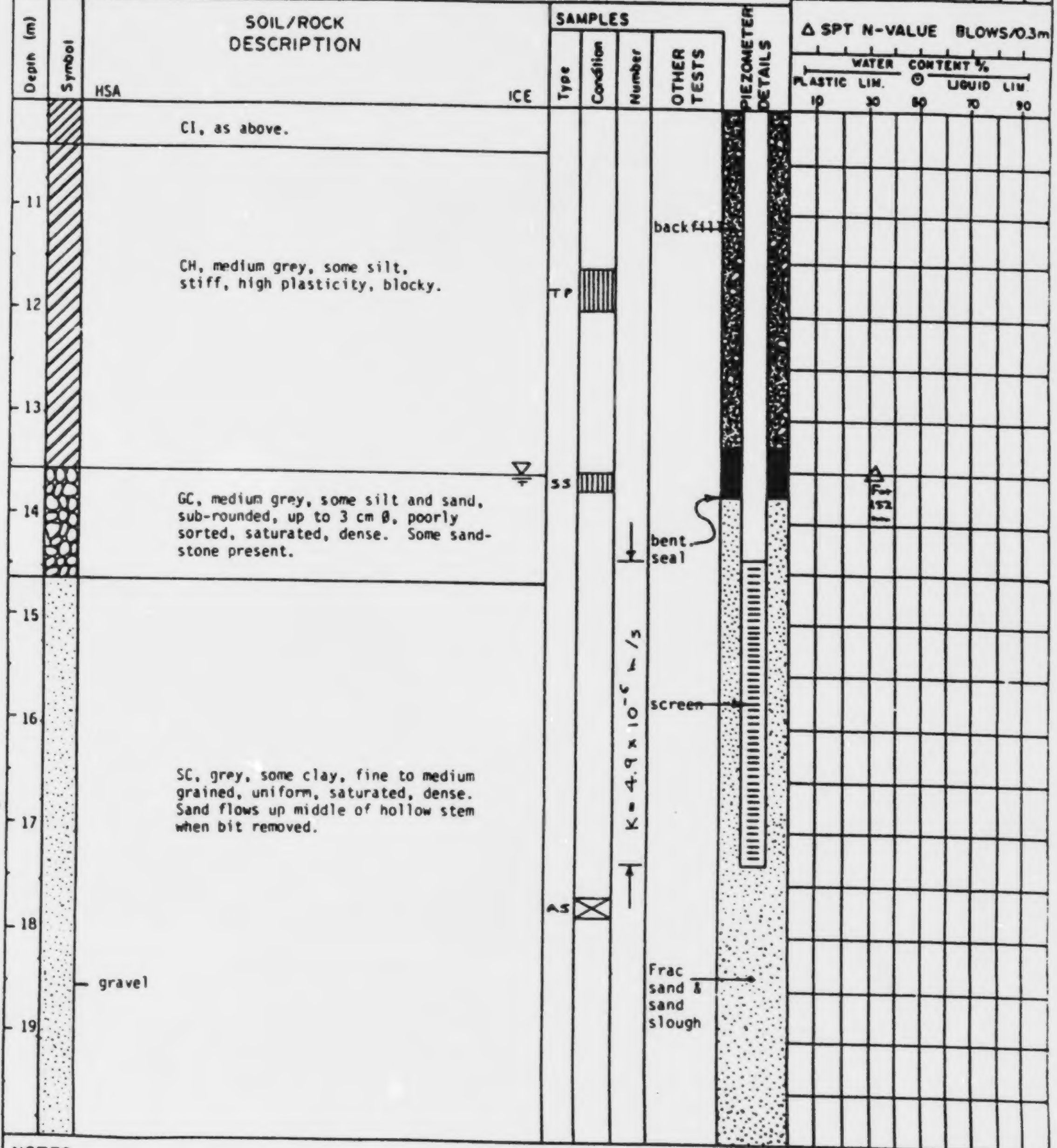
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

**SAMPLE CONDITION**

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

**TEST INFORMATION**

● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM.



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
11
12
13
14
15
16
17
18
19
TP
SS
AS
backfill
bent. seal
screen
Frac sand & sand slough
K = 4.9 × 10⁻⁶ m/s
For 152
gravel

CI, as above.

CH, medium grey, some silt, stiff, high plasticity, blocky.

GC, medium grey, some silt and sand, sub-rounded, up to 3 cm Ø, poorly sorted, saturated, dense. Some sandstone present.

SC, grey, some clay, fine to medium grained, uniform, saturated, dense. Sand flows up middle of hollow stem when bit removed.

NOTES:

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# OFFICE REPORT ON SITE INVESTIGATION

Sheet 3 of 3

Contract No. A85-2097
Boring No. B - P1
Northing 5554013.059 m

Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18666.674 m

Boring Date August 9 & 10, 1985
Contractor Allkind Drilling
Elevation 1033.813 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION HSA ICE | SAMPLES Type | SAMPLES Condition | SAMPLES Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|
| | ▒ | SC, as above. | | | | Frac sand & sand slough | ▒ |
| 21 | | End of Hole @ 20.73 m. | | | | | |

NOTES:

JOB NO. 2097 BORING NO. B - P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. A85-2097
Boring No. B-P2
Northing 5554014.462 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18666.267 m
Boring Date August 12, 1985
Contractor Allkind Drilling
Elevation 1033.783 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

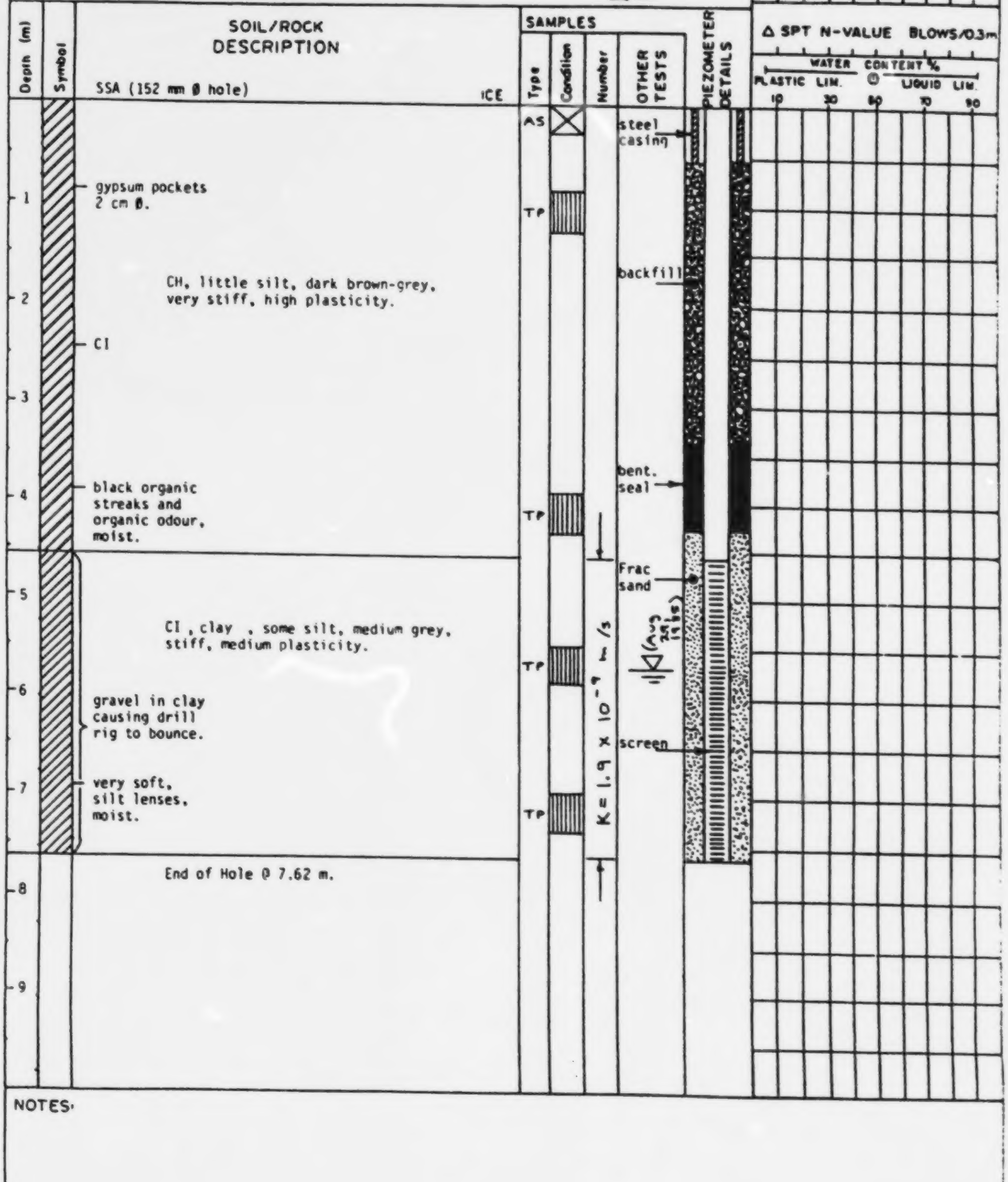
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ◎ LIQUID LIM.

SOIL/ROCK DESCRIPTION

SSA (152 mm Ø hole)



Depth (m)
Symbol
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
TP
TP
steel casing
backfill
bent. seal
Frac sand
screen
(Aug 29 1985)
K = 1.9 x 10⁻⁹ m/s

- gypsum pockets 2 cm Ø.

CH, little silt, dark brown-grey, very stiff, high plasticity.

- CI

- black organic streaks and organic odour, moist.

CI, clay, some silt, medium grey, stiff, medium plasticity.

- gravel in clay causing drill rig to bounce.

- very soft, silt lenses, moist.

End of Hole @ 7.62 m.

NOTES:

JOB NO. 2097 BORING NO. B-P2

| | |
|---|---|
| **PITEAU ENGINEERING LTD.**<br>GEOTECHNICAL CONSULTANTS | **OFFICE REPORT ON SITE INVESTIGATION** Sheet 1 of 2 |

Contract No. A85-2097
Boring No. C-P1
Northing 5553856,670 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18515,985 m
Boring Date August 11, 1985
Contractor Allkind Drilling
Elevation 1033.827 m (Ground)

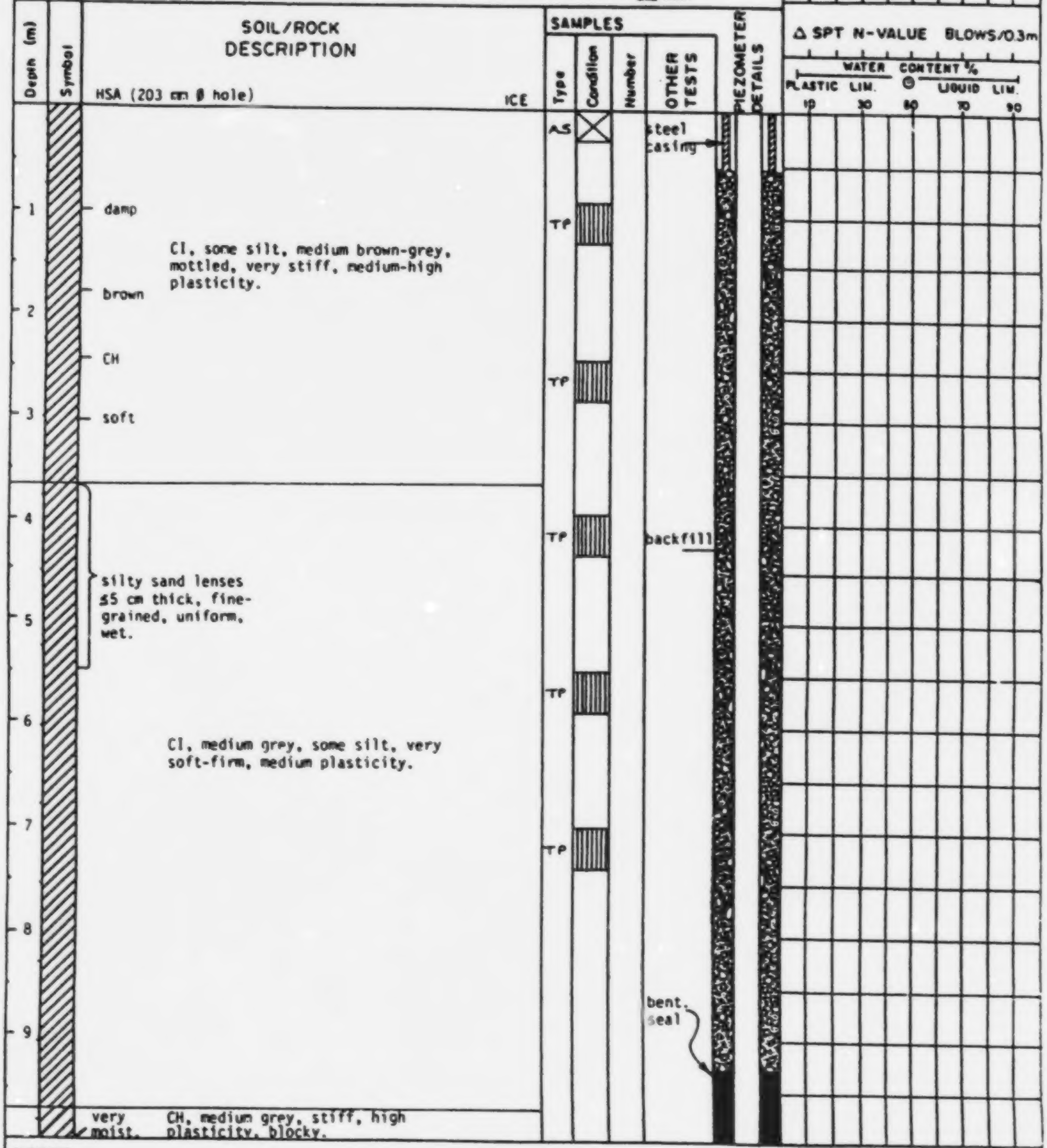
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA (203 mm ∅ hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
TP
TP
TP
steel casing
backfill
bent. seal

- damp (1 m)
- brown (2 m)
- CH
- soft (3 m)

CI, some silt, medium brown-grey, mottled, very stiff, medium-high plasticity.

silty sand lenses ≤5 cm thick, fine-grained, uniform, wet.

CI, medium grey, some silt, very soft-firm, medium plasticity.

very moist. CH, medium grey, stiff, high plasticity, blocky.

NOTES:

JOB NO. 2097 BORING NO. C-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 11, 1985 |
| Boring No. C-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5553856.670 m | Easting 18515.985 m | Elevation 1033.827 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted

SAMPLE HAMMER: wt. 140 lb drop 30 in

WEATHER

SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION

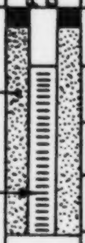
● PENETROMETER KN/m²

☐ UNCONFINED COMP STR KN/m²

△ SPT N-VALUE BLOWS/0.3m

WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION<br>HSA (203 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|
| | ▨ | | | TS | ▥ | | | |
| 11 | ▨ | CH, medium grey, little-some silt, stiff, high plasticity, blocky. | | | | | Frac sand | |
| 12 | ▨ | silty sand layers, very moist. | | TP | ▥ | | screen | |



NOTES:

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GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. A85-2097
Compiled By B.J. Rutherford
Boring Date August 11, 1985
Boring No. C-P2
Location Pine Coulee
Contractor Allkind Drilling
Northing 5553856.446 m
Easting 18813.254 m
Elevation 1033.842 m (Ground)

**SAMPLE TYPES**

| | |
|---|---|
| AS | Auger sample |
| WS | Wash sample |
| RC | Rock core |
| CR | CRREL barrel |
| SS | Split spoon |
| TO | Thin wall open |
| TP | Thin wall piston |

TYPE OF RIG 861 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

**SAMPLE CONDITION**

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

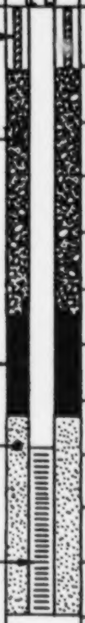
**TEST INFORMATION**

● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM
10 30 50 70 90

SSA (152 mm Ø hole) ICE

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|
| 0 | ▨ | CI, some silt, medium brown-grey, mottled, very stiff, medium-high plasticity. | AS | ☒ | | steel casing |
| 1 | ▨ | – damp | TP | ▥ | | backfill |
| 2 | ▨ | – brown | | | | |
| 2.5 | ▨ | – CH | TP | ▥ | | |
| 3 | ▨ | – soft | | | | bent. seal |
| 3.7 | ▨ | CI, medium grey, some silt, very soft-firm, medium plasticity. silty sand lenses, ≤5 cm thick, fine-grained, uniform, wet. | | | | |
| 4 | ▨ | | TP | ▥ | K=6.6×10⁻⁹ m/s | Frac sand |
| 5 | ▨ | | AS | ☒ | | screen |
| 5.49 | | End of Hole @ 5.49 m. | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |

PIEZOMETER DETAILS



Dry
(Aug 29,
1985)

NOTES:

JOB NO. 2097. BORING NO. C-P2

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# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. ABS-2097 | Compiled By B.J. Rutherford | Boring Date August 12, 1985 |
| Boring No. D-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5554184.043 m | Easting 18520.420 m | Elevation 1033.629 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

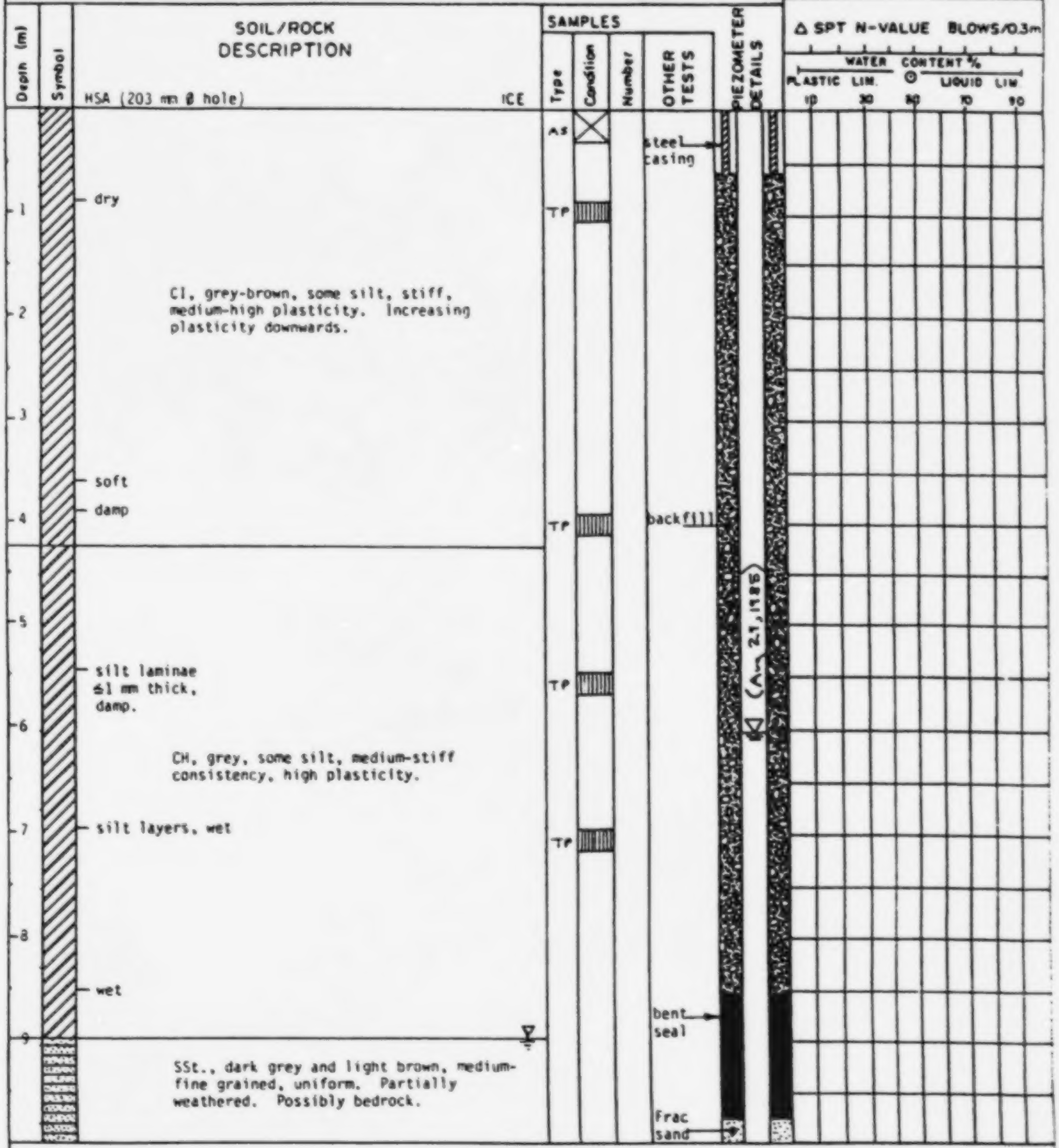
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION

● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
HSA (203 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM.
⊙
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
TP
TP
steel casing
backfill
bent seal
Frac sand
(Aug 21, 1985)

- dry
- soft
- damp

CI, grey-brown, some silt, stiff, medium-high plasticity. Increasing plasticity downwards.

- silt laminae ≤1 mm thick, damp.
- silt layers, wet
- wet

CH, grey, some silt, medium-stiff consistency, high plasticity.

SSt., dark grey and light brown, medium-fine grained, uniform. Partially weathered. Possibly bedrock.

NOTES:

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

Contract No. A85-2097
Boring No. D-P1
Northing 5554184.043 m.
Compiled By R.J. Rutherford
Location Pine Coulee
Easting 18520.420 m
Boring Date August 12, 1985
Contractor Allkind Drilling
Elevation 1033.629 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

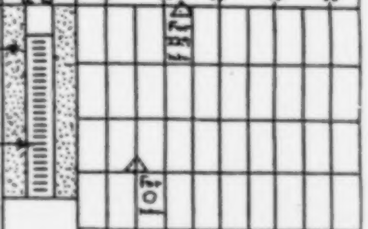
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % ⊙ PLASTIC LIM. LIQUID LIM.
10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION HSA (203 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|---|
| 11 | | SSt., dark grey and light brown, medium-fine grained, uniform. Partially weathered. Possibly bedrock. | | SS<br>SS | ▥ | $K = 6.7 \times 10^{-8}$ m/s | Frac sand<br>screen |
| | | End of Hole @ 11.73 m. | | | | | |

PIEZOMETER DETAILS



NOTES:

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. A85-2097
Boring No. D-P2
Northing 5554183.645 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18519.109 m
Boring Date August 12, 1985
Contractor Allkind Drilling
Elevation 1033.644 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

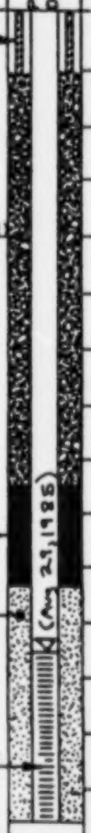
SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT %: PLASTIC LIM. ⊙ LIQUID LIM. 10 30 50 70 90

SSA (152 mm ⌀ hole) ICE

| Depth (m) | Symbol | Soil/Rock Description | Type | Condition | Number | Other Tests |
|---|---|---|---|---|---|---|
| 0 | ▨ | | AS | ☒ | | steel casing |
| 1 | ▨ | dry | TP | ▥ | | |
| 1.5 | ▨ | CI, grey-brown, some silt, stiff, medium-high plasticity. Increasing plasticity downwards. | | | | |
| 2 | ▨ | | | | | backfill |
| 3.6 | ▨ | soft | | | | |
| 3.9 | ▨ | damp | | | | |
| 4 | ▨ | | TP | ▥ | | |
| 5 | ▨ | CH, grey, some silt, medium-stiff consistency, high plasticity. | | | | bent. seal |
| 5.4 | ▨ | silt laminae 1 mm thick, damp. | | | | Frac sand |
| 5.7 | ▨ | | TP | ▥ | | |
| 6.9 | ▨ | silt layers, wet. | | | | screen |
| 7.1 | ▨ | | TP | ▥ | | |
| 7.32 | | End of Hole @ 7.32 m. | | | | |

K=7.5 × 10⁻⁷ m/s



NOTES:

JOB NO. 2097 BORING NO. D-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 13, 1985 |
| Boring No. F-P1 | Location Pioe Coulee | Contractor Allkind Drilling |
| Northing 5553897.237 m | Easting 19249.228 m | Elevation 1045.809 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

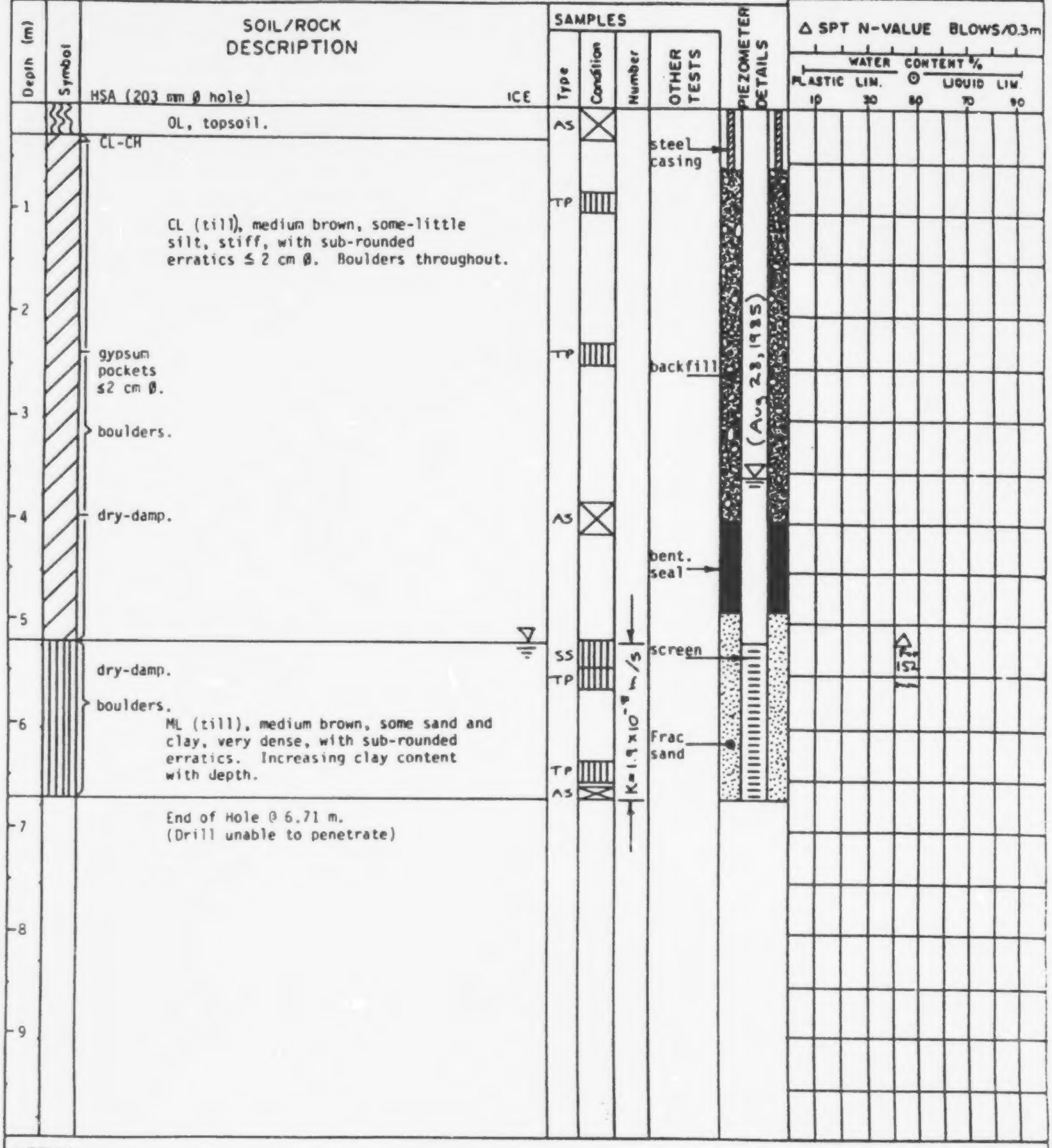
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION

- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
AS
SS
TP
TP
AS
steel casing
backfill
bent. seal
screen
Frac sand
(Aug 28, 1985)
K=1.9x10⁻⁸ m/s
152

HSA (203 mm Ø hole)

OL, topsoil.

CL-CH

CL (till), medium brown, some-little silt, stiff, with sub-rounded erratics ≤ 2 cm Ø. Boulders throughout.

gypsum pockets ≤2 cm Ø.

boulders.

dry-damp.

dry-damp.

boulders.

ML (till), medium brown, some sand and clay, very dense, with sub-rounded erratics. Increasing clay content with depth.

End of Hole @ 6.71 m.
(Drill unable to penetrate)

NOTES:

JOB NO. 2097 BORING NO. F-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 13, 1985 |
| Boring No. G-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5554084.888 m | Easting 20867.817 m | Elevation 1042.074 m (Ground) |

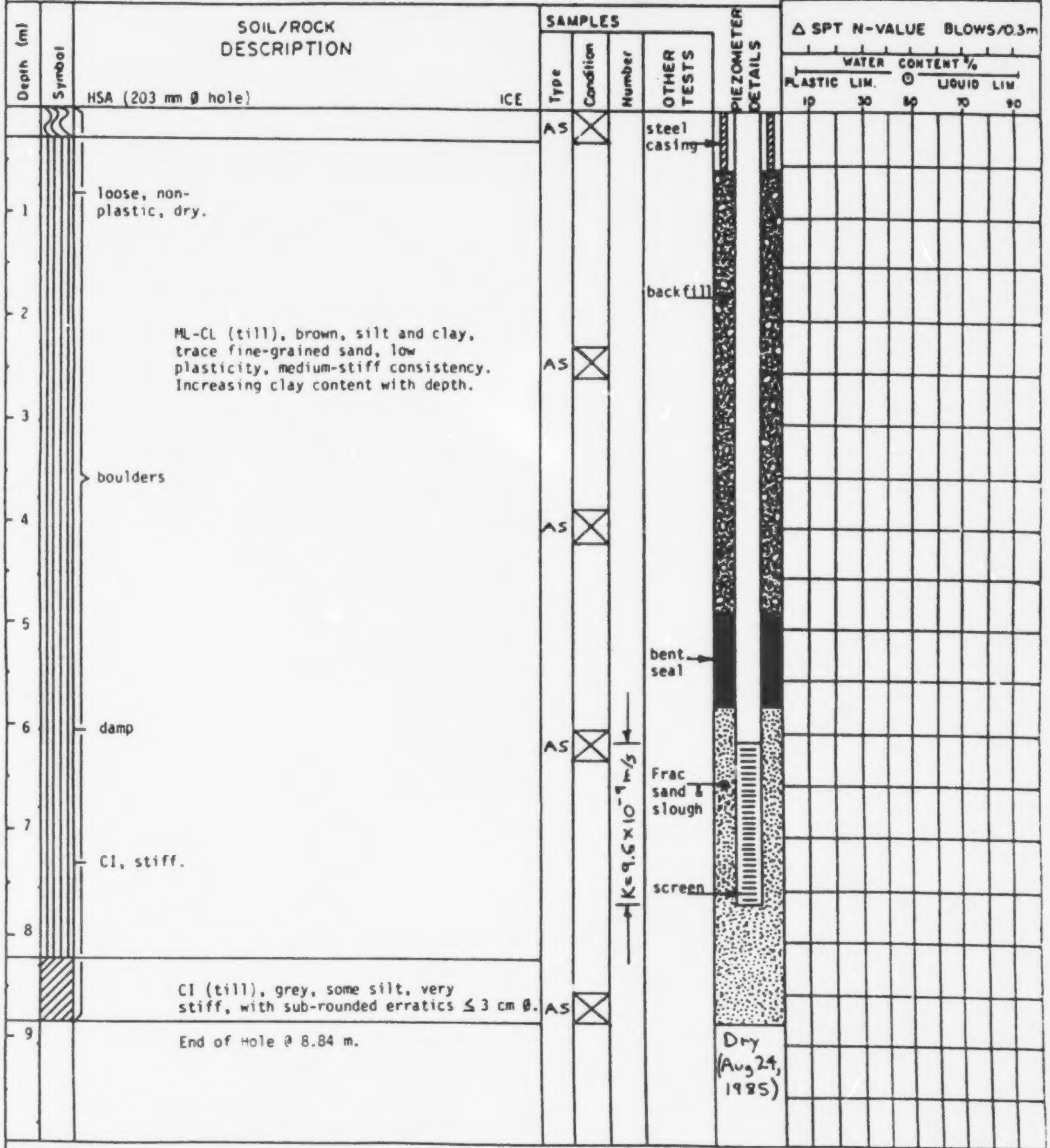
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
AS
AS
AS
AS
steel casing
backfill
bent. seal
Frac sand & slough
screen
K=9.6×10⁻⁹ m/s

HSA (203 mm Ø hole)

loose, non-plastic, dry.

ML-CL (till), brown, silt and clay, trace fine-grained sand, low plasticity, medium-stiff consistency. Increasing clay content with depth.

boulders

damp

CI, stiff.

CI (till), grey, some silt, very stiff, with sub-rounded erratics ≤ 3 cm Ø.

End of Hole @ 8.84 m.

Dry (Aug 24, 1985)

NOTES:

JOB NO. 2097 BORING NO. G-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 3

Contract No. A85-2097
Boring No. G-P2
Northing 5554083.292 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20862.632 m
Boring Date August 13, 20, 22, 1985
Contractor Allkind Drilling
Elevation 1042.064 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

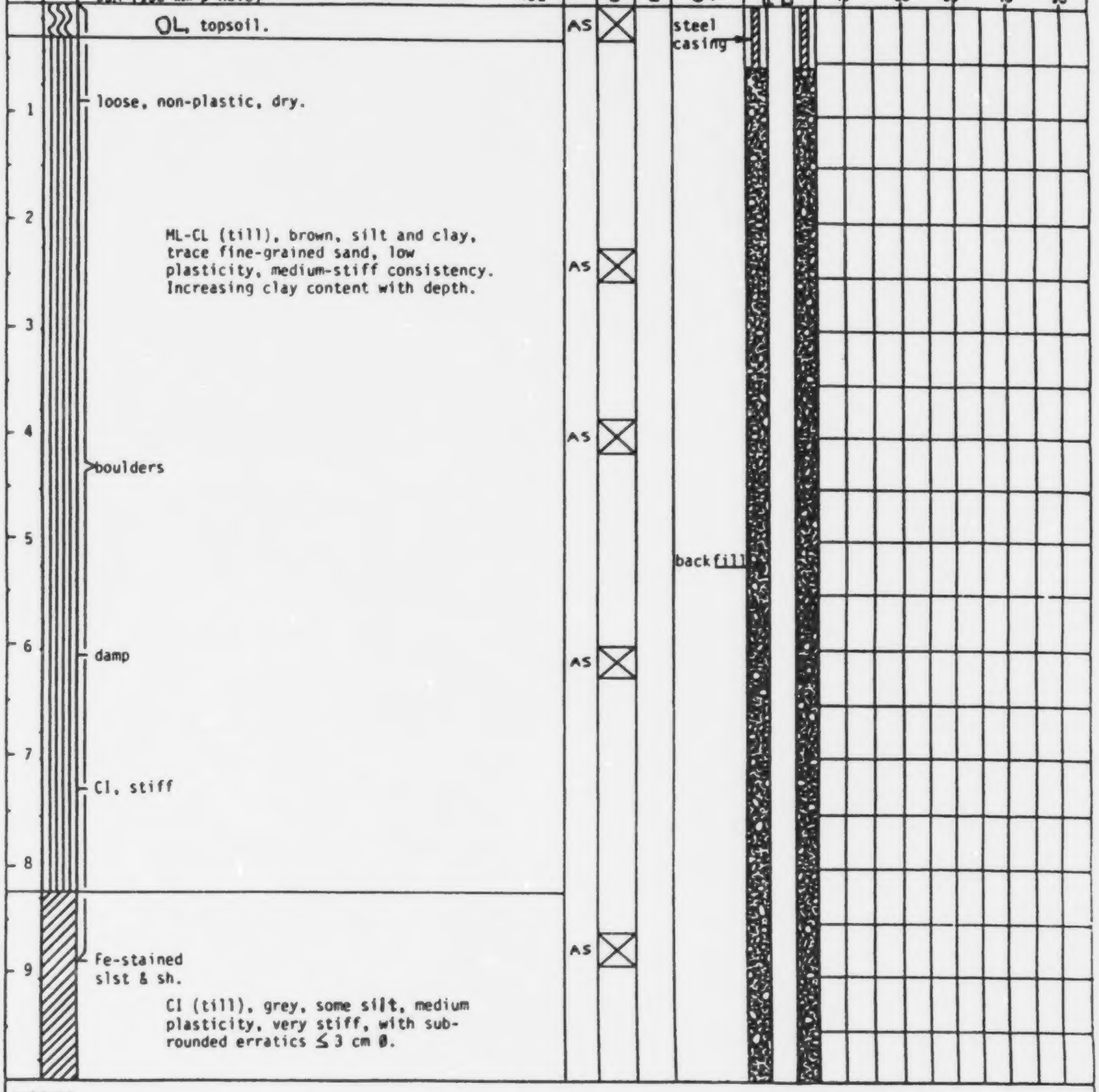
SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²
- △ SPT N-VALUE BLOWS/0.3m

WATER CONTENT %
PLASTIC LIM. ⊙ LIQUID LIM.

Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | SAMPLES: Type, Condition, Number, OTHER TESTS | PIEZOMETER DETAILS

SSA (152 mm Ø hole) ICE



OL, topsoil.

loose, non-plastic, dry.

ML-CL (till), brown, silt and clay, trace fine-grained sand, low plasticity, medium-stiff consistency. Increasing clay content with depth.

boulders

damp

CI, stiff

Fe-stained slst & sh.

CI (till), grey, some silt, medium plasticity, very stiff, with sub-rounded erratics ≤ 3 cm Ø.

steel casing

backfill

NOTES:

JOB NO. 2097 BORING NO. G-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 3

Contract No. A85-2097
Boring No. G-P2
Northing 5554083.292 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20867.632 m
Boring Date August 13, 20, 22, 1985
Contractor Allkind Drilling
Elevation 1042.064 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM.
10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION<br>SSA (152 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|
| | ▨ | | | AS | ☒ | | | |
| 11 | ▨ | brown CI layers ≤2 mm thick. | | | | | backfill | (Aug 29, 1985) |
| 12 | ▨ | CI (till), grey, some silt, medium-high plasticity, very stiff, with sub-rounded erratics ≤ 2 cm Ø. | | AS | ☒ | | | ▽ |
| 13 | ▨ | grey-brown | | AS | ☒ | | | |
| 14 | ▨ | | | | | | | |
| 15 | ▨ | | | AS | ☒ | | | |
| 16 | ▨ | | | AS | ☒ | | | |
| 17 | ▨ | | | | | | | |
| 18 | ▨ | | | | | | | |
| 19 | ▨ | damp | | AS | ☒ | | | |

NOTES:

JOB NO. 2097. BORING NO. G-P2.

PITEAU ENGINEERING LTD.
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 3 of 3

Contract No. A85-2097
Boring No. G-P2
Northing 5554083.292 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20867.632 m
Boring Date August 13, 20, 22, 1985
Contractor Allking Drilling
Elevation 1042.064 m (Ground)

SAMPLE TYPES

| | |
|---|---|
| AS | Auger sample |
| WS | Wash sample |
| RC | Rock core |
| CR | CRREL barrel |
| SS | Split spoon |
| TO | Thin wall open |
| TP | Thin wall piston |

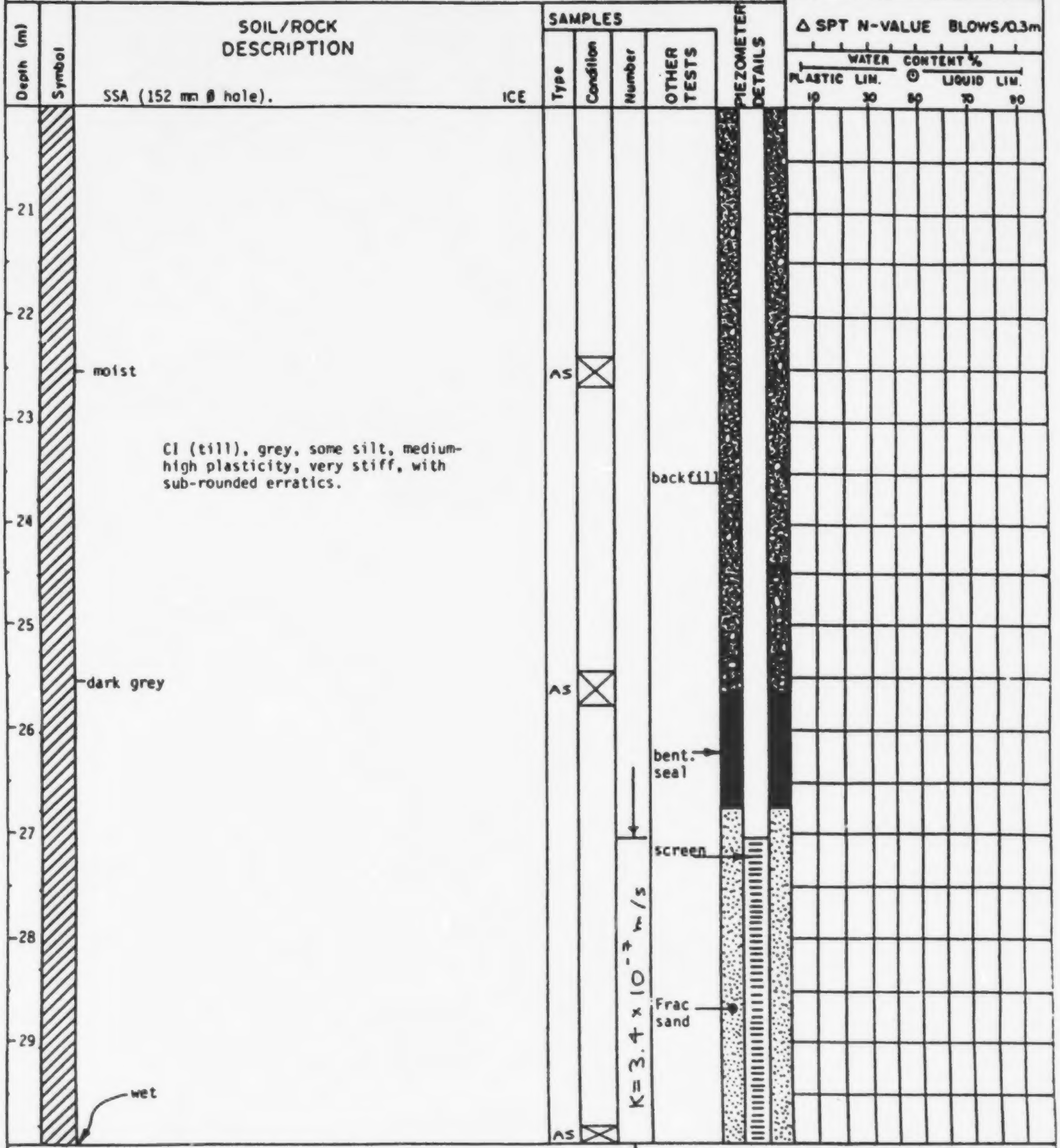
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

| | |
|---|---|
| ☒ | Disturbed |
| ▥ | Fair |
| ▨ | Good |
| ■ | Lost |

TEST INFORMATION

● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
21
22
23
24
25
26
27
28
29
AS
AS
AS
backfill
bent. seal
screen
Frac sand

SSA (152 mm Ø hole).

- moist

CI (till), grey, some silt, medium-high plasticity, very stiff, with sub-rounded erratics.

- dark grey

- wet

K = 3.4 × 10⁻⁷ m/s

NOTES: End of Hole @ 30.02 m.

JOB NO. 2097 BORING NO. G-P2

7

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 14, 1985 |
| Boring No. H-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5555205.480 m | Easting 19934.045 m | Elevation 1041.932 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted

SAMPLE HAMMER: wt. 140 lb drop 30 in

WEATHER

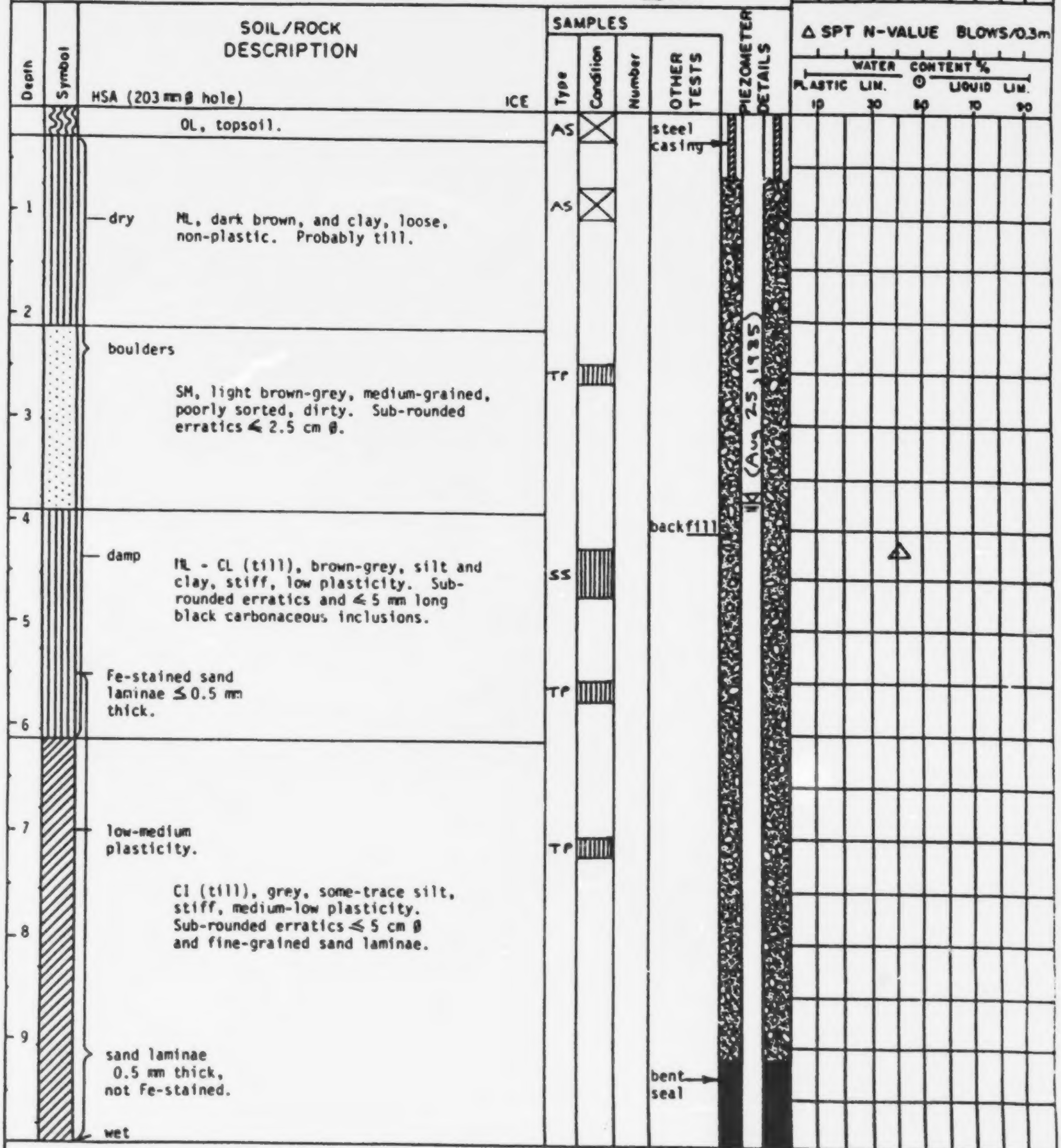
SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION

- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²

△ SPT N-VALUE BLOWS/0.3m



SOIL/ROCK DESCRIPTION
Depth
Symbol
HSA (203 mm ∅ hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
AS
TP
SS
TP
TP
steel casing
backfill
bent. seal
(Aug 25, 1985)

OL, topsoil.

dry — ML, dark brown, and clay, loose, non-plastic. Probably till.

boulders — SM, light brown-grey, medium-grained, poorly sorted, dirty. Sub-rounded erratics ≤ 2.5 cm ∅.

damp — ML - CL (till), brown-grey, silt and clay, stiff, low plasticity. Sub-rounded erratics and ≤ 5 mm long black carbonaceous inclusions.

Fe-stained sand laminae ≤ 0.5 mm thick.

low-medium plasticity.

CI (till), grey, some-trace silt, stiff, medium-low plasticity. Sub-rounded erratics ≤ 5 cm ∅ and fine-grained sand laminae.

sand laminae 0.5 mm thick, not Fe-stained.

wet

NOTES:

JOB NO. 2097 BORING NO. H-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

|  |  |  |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 14, 1985 |
| Boring No. H-PI | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5555205.480 m | Easting 19934.045 m | Elevation 1041.932 m (Ground) |

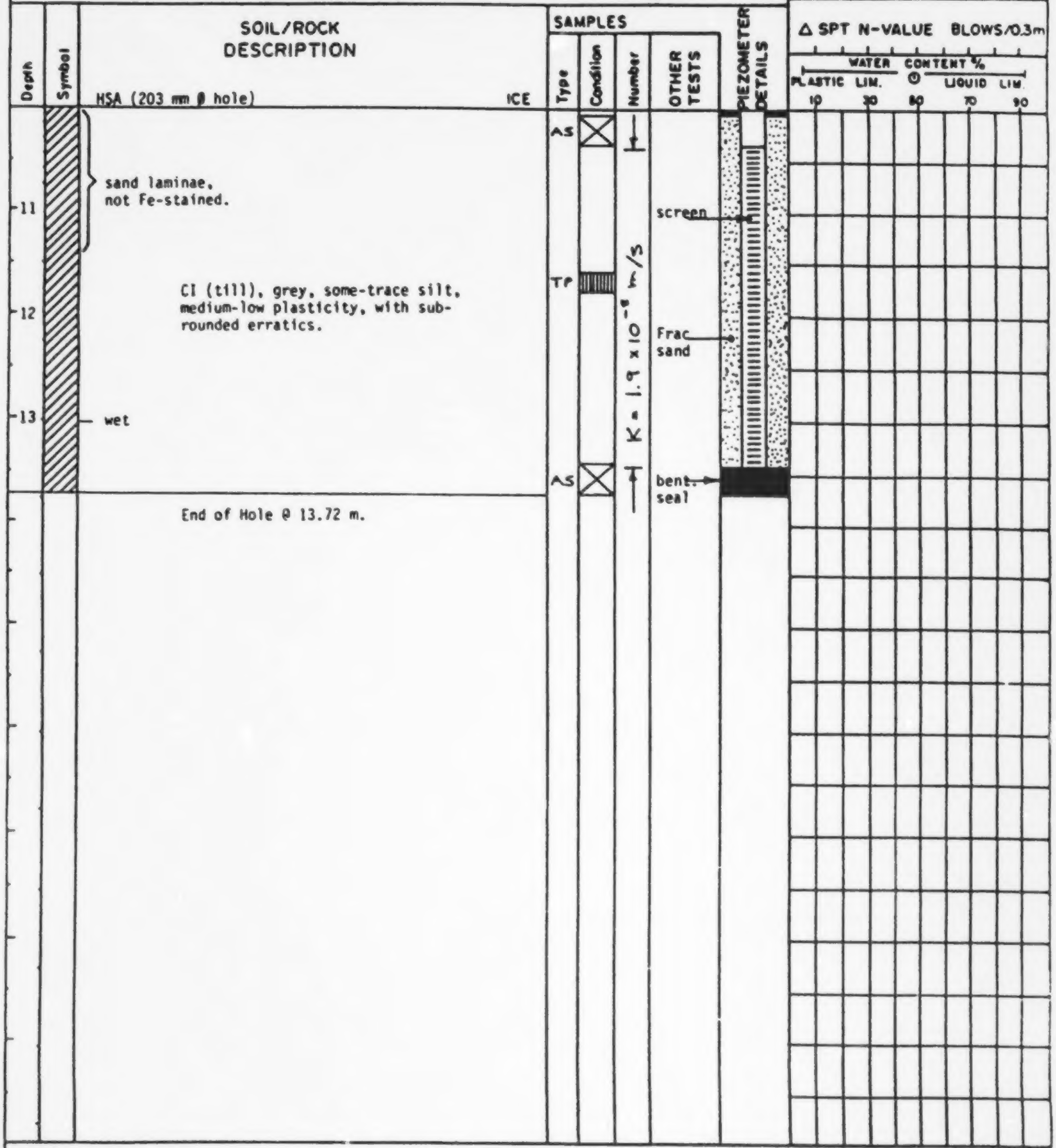
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²


Depth
Symbol
SOIL/ROCK DESCRIPTION
HSA (203 mm ∅ hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
11
12
13
AS
TP
AS
K = 1.9 x 10⁻⁸ m/s
screen
Frac sand
bent. seal

sand laminae, not Fe-stained.

CI (till), grey, some-trace silt, medium-low plasticity, with sub-rounded erratics.

wet

End of Hole @ 13.72 m.

NOTES:

JOB NO. 2097. BORING NO. H-PI

| PITEAU ENGINEERING LTD.<br>GEOTECHNICAL CONSULTANTS | OFFICE REPORT ON SITE INVESTIGATION | Sheet 1 of 1 |
|---|---|---|

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 14, 1985 |
| Boring No. H-P2 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5555205.578 m | Easting 19932.298 m | Elevation 1041.952 m (Ground) |

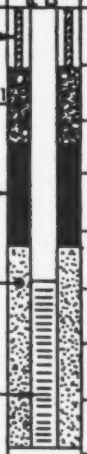
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.
10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION<br>SSA (152 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|
| | | OL, topsoil. | | AS | ☒ | | steel casing |  |
| 1<br>2 | dry | ML, dark brown, and clay, loose, non-plastic. Probably till. | | AS | ☒ | | backfill<br>bent seal | |
| 3 | boulders | SM, light brown-grey, medium grained, poorly sorted, dirty. Sub-rounded erratics ≤ 2.5 cm Ø. | | TP<br>AS | ▥<br>☒ | $K = 3.1 \times 10^{-3}$ m/s | Frac sand<br>screen | |
| 4<br>5<br>6<br>7<br>8<br>9 | | End of Hole @ 3.96 m. | | | | | | Dry (Aug 25, 1985) |

NOTES:

JOB NO. 2097 BORING NO. H-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 14, 1985 |
| Boring No. I - P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5555199.615 m | Easting 18417.848 m | Elevation 1062.971 m (Ground) |

SAMPLE TYPES

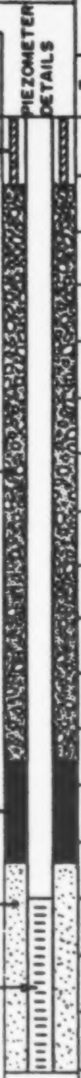
| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

| Depth | Symbol | SOIL/ROCK DESCRIPTION HSA (203 mm ⌀) and SSA (152 mm ⌀) ICE | Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS | TEST INFORMATION |
|---|---|---|---|---|---|---|---|---|
| | | OL, topsoil. | AS | ☒ | | steel casing | | |
| 1 | | – dry | TP | ▥ | | | | |
| 2 | | ML (till), light brown, and clay, trace fine-grained sand, low plasticity, medium consistency with sub-rounded erratics ≤ 2 cm ⌀. | | | | | | |
| 3 | | | | | | backfill | | |
| 4 | | – damp, grey | TP | ▥ | | | | |
| 5 | | | TP | ▥ | | | | |
| 6 | | ML - CL (till), brown, silt and clay, low plasticity, stiff, with sub-rounded erratics ≤ 10 cm. | SS | ▥ | | bent seal | | △ For 152 mm |
| 7 | | damp | AS | ☒ | K=1.6×10⁻⁷ m/s | Frac sand | | |
| 8 | | sandstone and shale layers. | AS | ☒ | | screen | | |
| 9 | | End of Hole @ 8.53 m. (Possible bedrock) | | | | | Dry (Aug 25, 1985) | |



NOTES:

JOB NO. 2097 BORING NO. I - P.I

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. A85-2097
Boring No. I-P2
Northing 5555199.612 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18816.707 m
Boring Date August 16, 1985
Contractor Allkind Drilling
Elevation 1063.071 m. (Ground)

SAMPLE TYPES

| | |
|---|---|
| AS | Auger sample |
| WS | Wash sample |
| RC | Rock core |
| CR | CRREL barrel |
| SS | Split spoon |
| TO | Thin wall open |
| TP | Thin wall piston |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

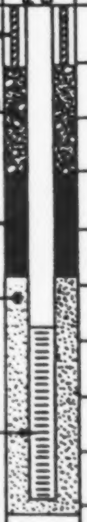
TEST INFORMATION

● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊖ LIQUID LIM. — 10 30 50 70 90

SSA (152 mm Ø hole)

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | ICE | Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|---|
| | | OL, topsoil. | | AS | ☒ | | steel casing |
| 1 | | – dry<br>ML (till), light brown, and clay, trace fine-grained sand, low plasticity, medium consistency with sub-rounded erratics ≤ 2 cm Ø. | | TP | ▥ | | backfill |
| 2 | | | | | | | bent seal |
| 3 | | | | | | $K=33\times10^{-8}$ m/s | Frac sand |
| 4 | | – damp, grey. | | TP<br>AS | ▥<br>☒ | | screen |
| 5 | | End of Hole @ 4.57 m. | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |

PIEZOMETER DETAILS



Dry (Aug 25, 1985)

NOTES:

JOB NO. 2097. BORING NO. I-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 15, 1985 |
| Boring No. J-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5556629.493 m | Easting 20840.020 m | Elevation 1050.700 m (Ground) |

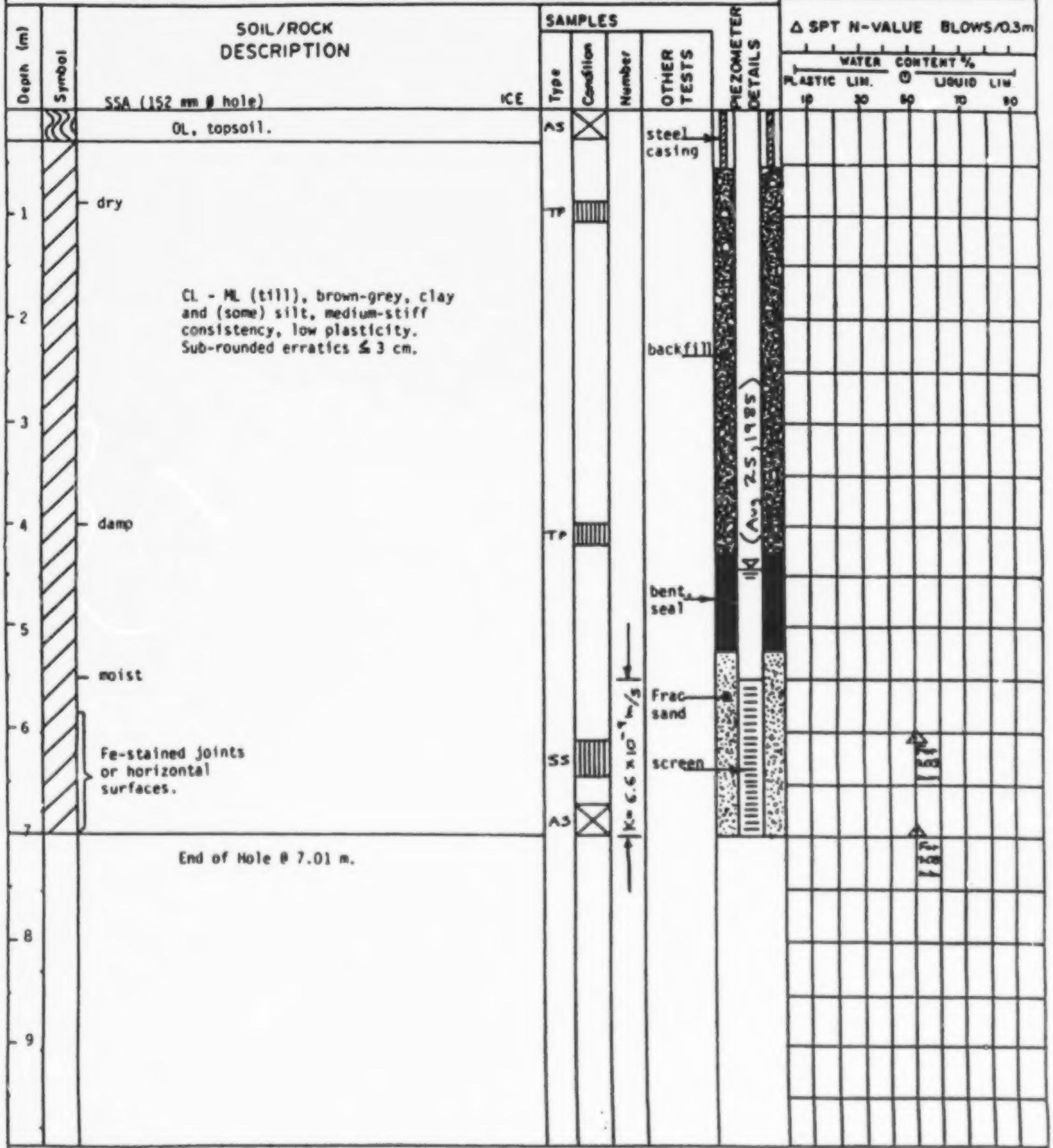
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM.


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
SS
AS
K= 6.6 x 10⁻⁹ m/s
steel casing
backfill
(Aug 25, 1985)
bent. seal
Frac sand
screen

OL, topsoil.

- dry

CL - ML (till), brown-grey, clay and (some) silt, medium-stiff consistency, low plasticity. Sub-rounded erratics ≤ 3 cm.

- damp

- moist

Fe-stained joints or horizontal surfaces.

End of Hole @ 7.01 m.

NOTES:

JOB NO. 2097 BORING NO. J-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. ABS-2097
Boring No. J-P2
Northing 5556630.881 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20840.175 m
Boring Date August 10, 1985
Contractor Allkind Drilling
Elevation 1050.770 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

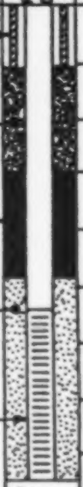
SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊙ LIQUID LIM.
10 30 50 70 90

SSA (152 mm Ø hole)

| Depth (m) | SOIL/ROCK DESCRIPTION | ICE | Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|
| | OL, topsoil. | | AS | ☒ | | steel casing |
| 1 | – dry<br>CL - ML (till), brown-grey, clay and (some) silt, medium-stiff consistency, low plasticity. Sub-rounded erratics ≤ 3 cm. | | TP | ▥ | | backfill |
| 2 | | | | | | bent. seal |
| 3 | | | | | K=9.0x10⁻⁸ m/s | Frac sand<br>screen |
| 4 | – damp | | TP | ▥ | | |
| | End of Hole @ 4.27 m. | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |

PIEZOMETER DETAILS



Dry (Aug 26, 1985)

NOTES:

JOB NO. 2035 BORING NO. J-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 3

|  |  |  |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 15 & 16, 1985 |
| Boring No. J - P3 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5556631.928 m | Easting 20840.215 m | Elevation 1050.760 m (Ground) |

SAMPLE TYPES

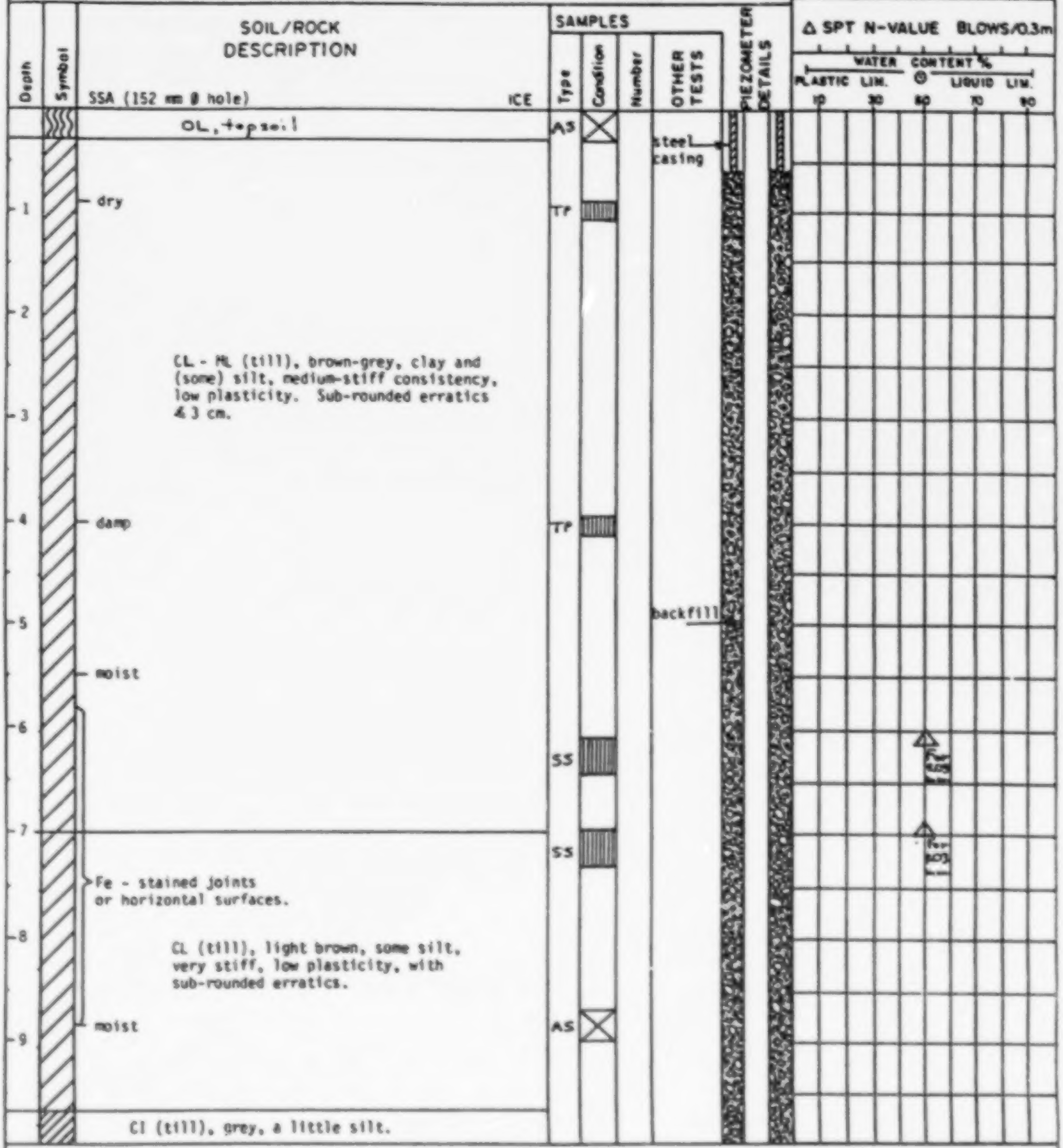
| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION

● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m


Depth
Symbol
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
1
2
3
4
5
6
7
8
9
AS
TP
TP
SS
SS
AS
steel casing
backfill

SOIL/ROCK DESCRIPTION

SSA (152 mm Ø hole) ICE

OL, topsoil

- dry

CL - ML (till), brown-grey, clay and (some) silt, medium-stiff consistency, low plasticity. Sub-rounded erratics ≤ 3 cm.

- damp

- moist

Fe - stained joints or horizontal surfaces.

CL (till), light brown, some silt, very stiff, low plasticity, with sub-rounded erratics.

- moist

CI (till), grey, a little silt.

NOTES:

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 3

Contract No. A85-2097
Boring No. J-P3
Northing 5556631.928 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20840.215 m
Boring Date August 15 & 16, 1985
Contractor Allkind Drilling
Elevation 1050.760 m (Ground)

SAMPLE TYPES
AS Auger sample
WS Wash sample
RC Rock core
CR CRREL barrel
SS Split spoon
TO Thin wall open
TP Thin wall piston

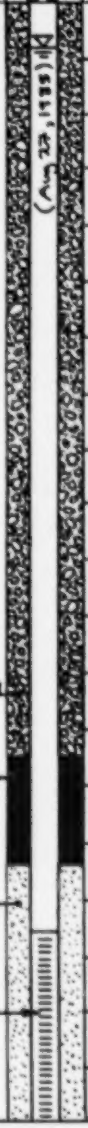
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.
10 30 50 70 90

| Depth | SOIL/ROCK DESCRIPTION<br>SSA (152 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|
|  | moist |  |  |  |  |  |
| 11 |  |  |  |  |  |  |
| 12 |  |  | AS | ☒ |  |  |
|  | CI (till), grey, a little to some silt, medium-stiff consistency, with sub-rounded erratics. |  |  |  |  |  |
| 13 | Fe - stained silty sst. layers ≤ 15 cm. |  |  |  |  |  |
| 14 |  |  |  |  |  |  |
| 15 |  |  | AS | ☒ |  |  |
| 16 |  |  |  |  |  | backfill |
|  | moist-wet |  |  |  |  |  |
| 17 |  |  |  |  |  | bent. seal |
| 18 | wet |  | AS | ☒ | $K = 1.4 \times 10^{-4}$ m/s | Frac sand |
| 19 |  |  |  |  |  | screen |

PIEZOMETER DETAILS



NOTES:

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 3 of 3

Contract No. A85-2097
Boring No. J - P3
Northing 5556631.928 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20840.215 m
Boring Date August 15 & 16, 1985
Contractor Allkind Drilling
Elevation 1050.760 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

| Depth | Symbol | SOIL/ROCK DESCRIPTION<br>SSA (152 mm ∅ hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|
| 21 | ▨ | CI (till), as above. | | AS | ☒ | K=1.4×10⁻⁹ m/s | screen<br>Frac sand | |
| | | End of Hole @ 21.34 m. | | | | | | |

NOTES:

JOB NO. 2097 BORING NO. J - P3

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 16, 1985 |
| Boring No. K-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561658.027 m | Easting 17156.446 m | Elevation 1084.922 m(Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted

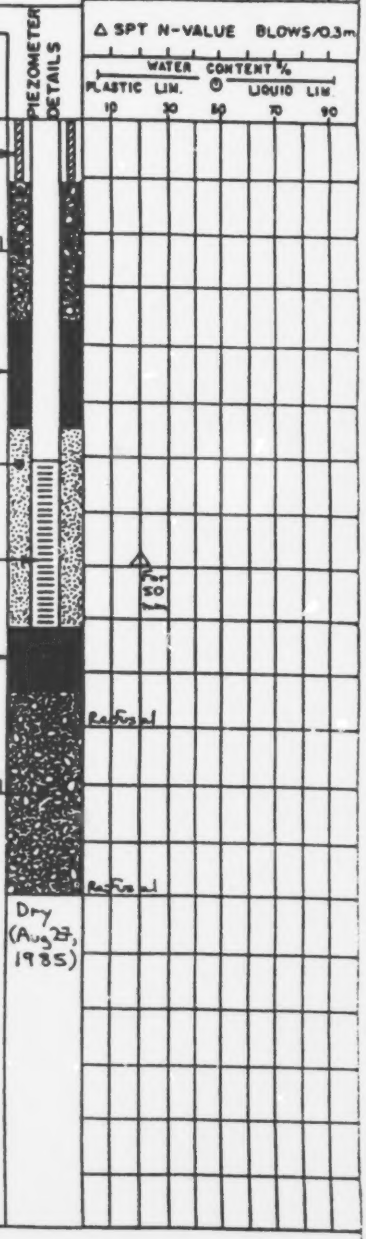
SAMPLE HAMMER: wt. 140 lb drop 30 in

WEATHER

SAMPLE CONDITION

☒ Disturbed
▥ Fair
▨ Good
■ Lost

| Depth (m) | SOIL/ROCK DESCRIPTION<br>HSA (203 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|
| | OL, topsoil. | | AS | ☒ | | steel casing |
| 1 | | | TP | ▥ | | backfill |
| 2 | ML, light-medium brown, little-some clay, very stiff-hard, low plasticity, with layers ≤15 cm thick of hard (partially indurated?) ML. | | AS | ☒ | | bent. seal |
| 3 | | | | | k=3.3 x $10^{-9}$ m/s | Frac sand |
| 4 | — dry | | SS | ▥ | | screen |
| 5 | | | | | | bent. sand |
| | | | SS | ▥ | | |
| 6 | CI, medium brown-grey, some-little silt, stiff, medium plasticity, with layers of soft shale and fine-grained sandstone. | | | | | backfill |
| 7 | | | AS | ☒ | | |
| | End of Hole @ 7.01 m. | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |


PIEZOMETER DETAILS
TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
For 50
Refusal
Refusal

Dry (Aug 27, 1985)

NOTES:

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By R.J. Rutherford | Boring Date August 17, 1985 |
| Boring No. K-P2 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561658.177 m | Easting 17157.883 m | Elevation 1084.932 m (Ground) |

**SAMPLE TYPES**

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

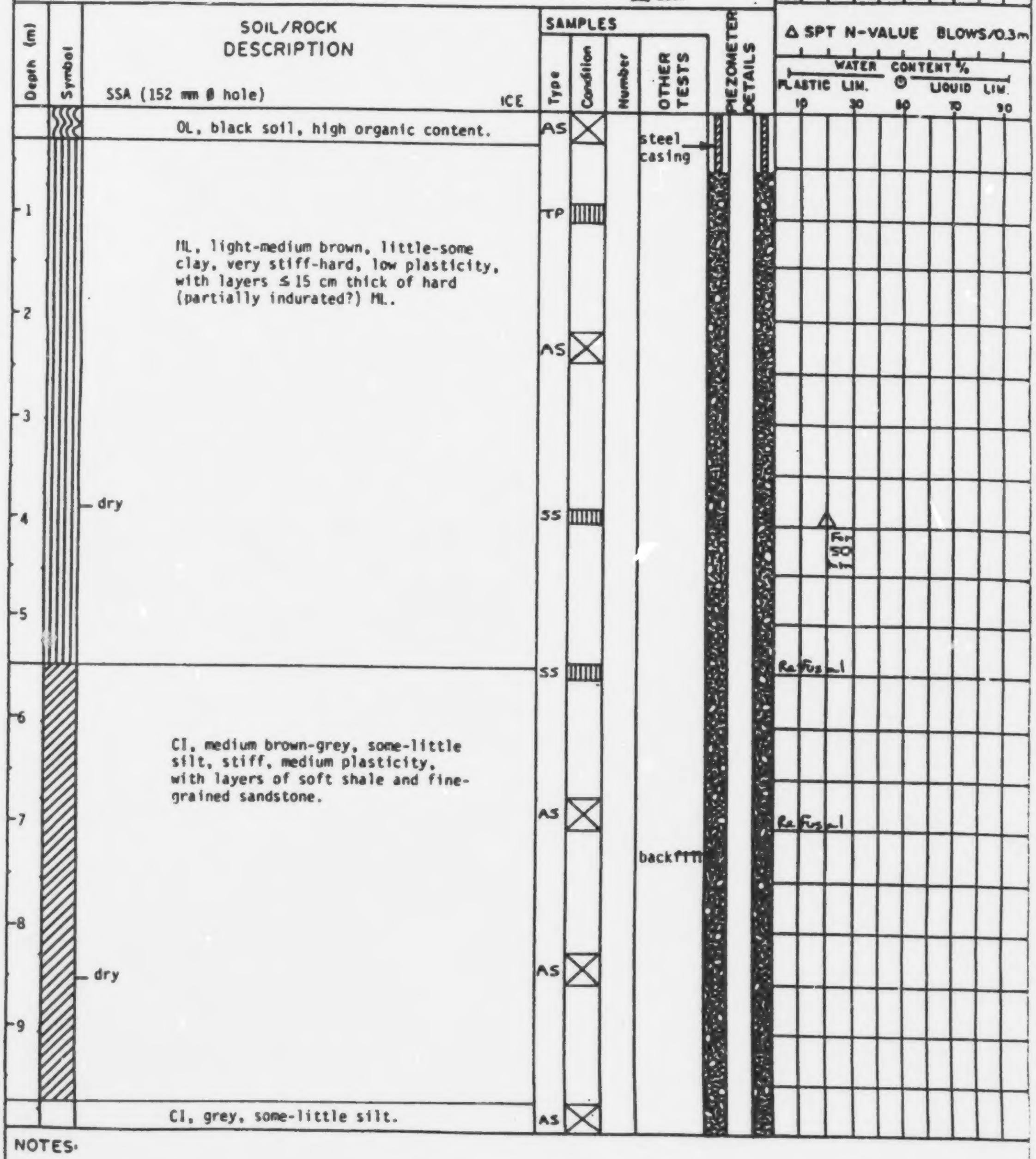
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

**SAMPLE CONDITION**

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

**TEST INFORMATION**

- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ⊖ LIQUID LIM.


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
1
2
3
4
5
6
7
8
9
dry
dry
steel casing
backfill
For
50
Refusal
Refusal

| SOIL/ROCK DESCRIPTION | Type | Condition |
|---|---|---|
| OL, black soil, high organic content. | AS | ☒ |
| ML, light-medium brown, little-some clay, very stiff-hard, low plasticity, with layers ≤ 15 cm thick of hard (partially indurated?) ML. | TP<br>AS<br>SS<br>SS | ▥<br>☒<br>▥<br>▥ |
| CI, medium brown-grey, some-little silt, stiff, medium plasticity, with layers of soft shale and fine-grained sandstone. | AS<br>AS | ☒<br>☒ |
| CI, grey, some-little silt. | AS | ☒ |

NOTES:

JOB NO. 2097 BORING NO. K-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

Contract No. A85-2097
Boring No. K-P2
Northing 5561658.177 m

Compiled By B.J. Rutherford.
Location Pine Coulee
Easting 17157.883 m

Boring Date August 17, 1985
Contractor Allkind Drilling
Elevation 1084.932 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

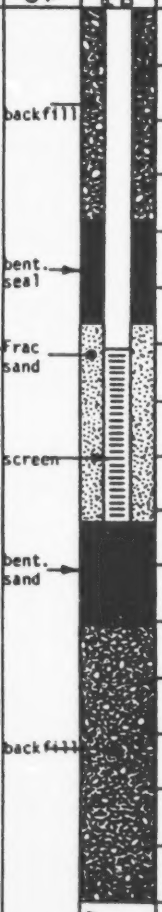
SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ⓪ LIQUID LIM. — 10 30 50 70 90

SSA (152 mm Ø hole)

| Depth (m) | SOIL/ROCK DESCRIPTION | ICE | SAMPLES Type | SAMPLES Condition | SAMPLES Number | OTHER TESTS |
|---|---|---|---|---|---|---|
| 11 | | | | | | |
| | dry | | AS | ☒ | | |
| 12 | | | | | | |
| | CI, grey, some-little silt, very stiff, with layers of very hard CI and soft siltstone and shale. | | | | | |
| 13 | | | | | K=3.4×10⁻⁹ m/s | |
| 14 | | | | | | |
| 15 | reddish-brown CI present. | | AS | ☒ | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | Shale, grey, hard. Possibly bedrock. | | AS | ☒ | | |
| | End of Hole @ 17.98 m (Minimal drilling progress) | | | | | |
| 19 | | | | | | |

PIEZOMETER DETAILS



Dry (Aug 27, 1985)

NOTES:

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

Contract No. A85-2097
Boring No. L-P1
Northing 5561655.578 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18161.047 m
Boring Date August 17, 1985
Contractor Allkind Drilling
Elevation 1059.918 m (Ground)

SAMPLE TYPES

| | |
|---|---|
| AS | Auger sample |
| WS | Wash sample |
| RC | Rock core |
| CR | CRREL barrel |
| SS | Split spoon |
| TO | Thin wall open |
| TP | Thin wall piston |

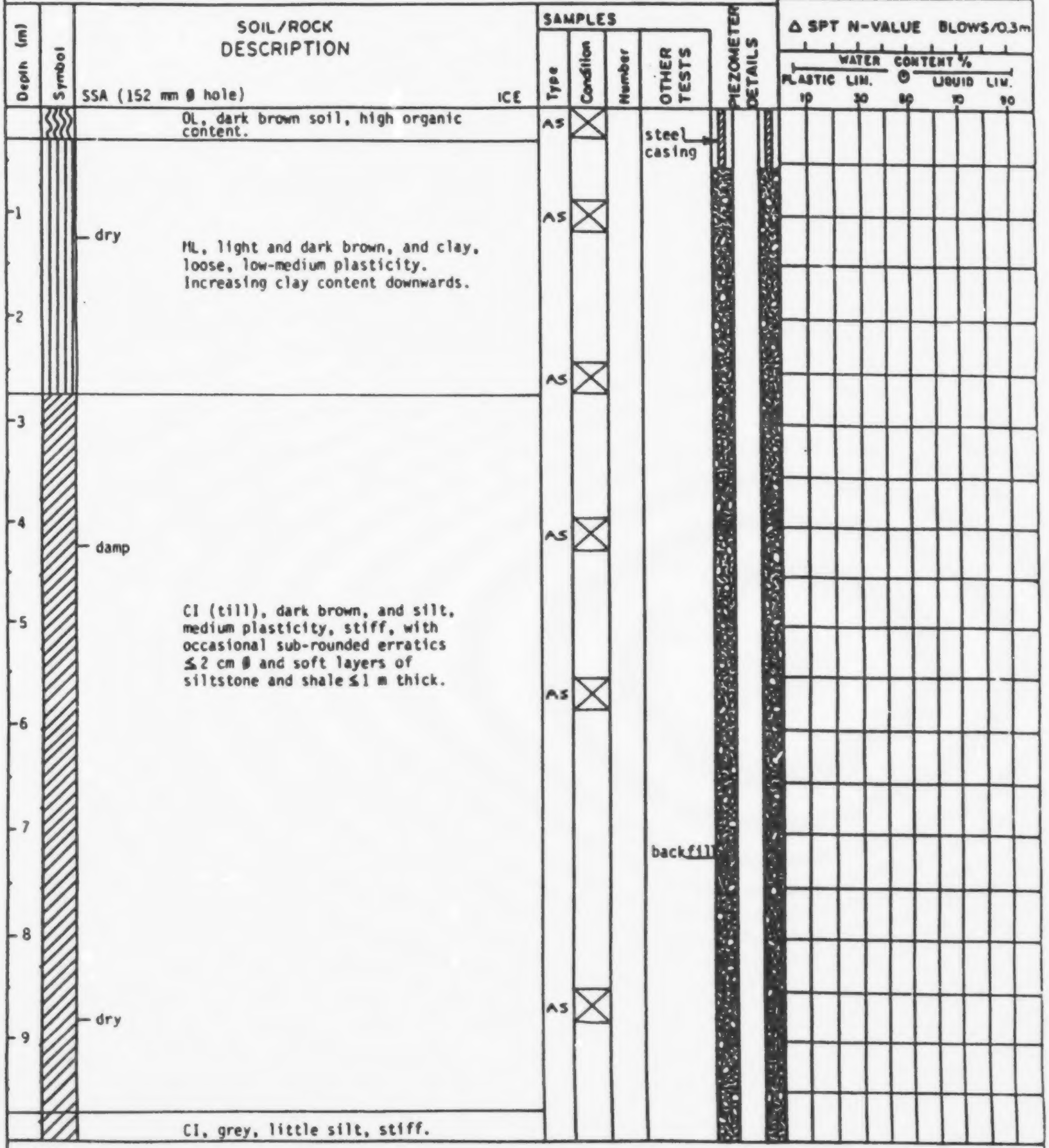
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION

● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.
10 30 50 70 90



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
1
2
3
4
5
6
7
8
9
dry
damp
dry
AS
AS
AS
AS
AS
AS
steel casing
backfill

OL, dark brown soil, high organic content.

ML, light and dark brown, and clay, loose, low-medium plasticity. Increasing clay content downwards.

CI (till), dark brown, and silt, medium plasticity, stiff, with occasional sub-rounded erratics ≤2 cm ø and soft layers of siltstone and shale ≤1 m thick.

CI, grey, little silt, stiff.

NOTES:

JOB NO. 2097 BORING NO. L-P1

| PITEAU ENGINEERING LTD.<br>GEOTECHNICAL CONSULTANTS | OFFICE REPORT ON SITE INVESTIGATION | Sheet 2 of 2 |
|---|---|---|

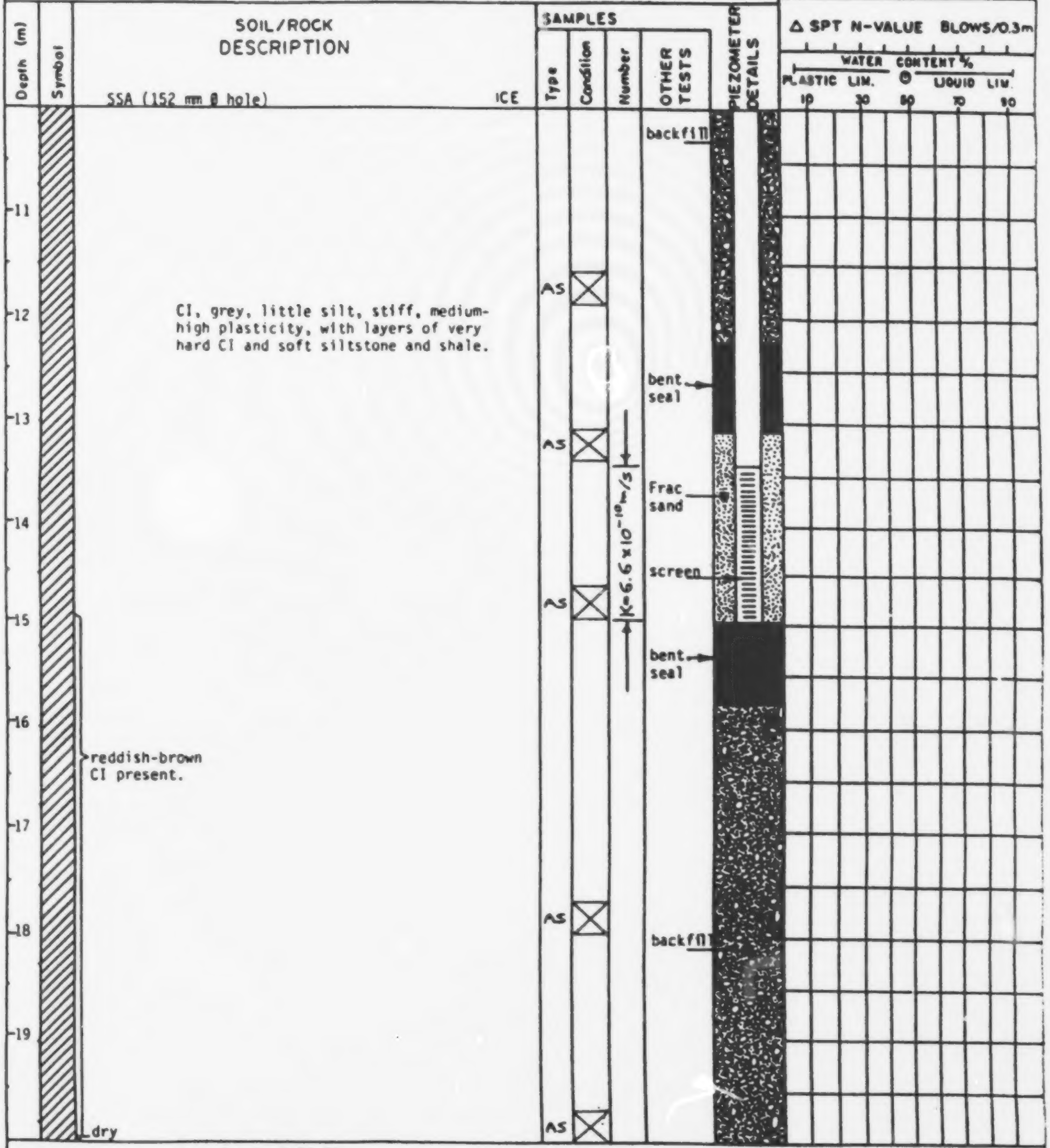
Contract No. A85-2097
Boring No. L-P1
Northing 5561655.578 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 18161.047 m
Boring Date August 17, 1985
Contractor Allkind Drilling
Elevation 1059.918 m (Ground)

SAMPLE TYPES
AS Auger sample
WS Wash sample
RC Rock core
CR CRREL barrel
SS Split spoon
TO Thin wall open
TP Thin wall piston

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
11
12
13
14
15
16
17
18
19
AS
AS
AS
AS
AS
K=6.6×10⁻¹⁰ m/s
backfill
bent. seal
Frac sand
screen
bent. seal
backfill
dry

CI, grey, little silt, stiff, medium-high plasticity, with layers of very hard CI and soft siltstone and shale.

reddish-brown CI present.

NOTES: End of Hole @ 20.73 m.

Dry (Aug 27, 1985)

JOB NO. 2097 BORING NO. L-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 17, 1985 |
| Boring No. L-P2 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561655.541 m | Easting 18162.480 m | Elevation 1059.818 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION

- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

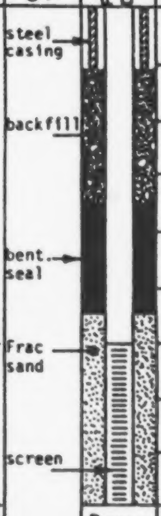
TEST INFORMATION

● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

SSA (152 mm Ø hole)

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | ICE | Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|---|
| | | OL, topsoil. | | AS | ☒ | | |
| 1<br>2 | | ML, light and dark brown, and clay, loose, low-medium plasticity. Increasing clay content downwards.<br>– dry | | AS<br>AS | ☒<br>☒ | | |
| 3<br>4 | | CI (till), dark brown, and silt, medium plasticity, stiff, with occasional sub-rounded erratics ≤ 2 cm Ø and soft layers of siltstone and shale ≤ 1 m thick.<br>– damp | | AS | ☒ | $K = 5.2 \times 10^{-8}$ m/s | |
| 5<br>6<br>7<br>8<br>9 | | End of Hole @ 4.57 m. | | | | | |

PIEZOMETER DETAILS



Dry (Aug 27, 1985)

NOTES:

JOB NO. 2097. BORING NO. L-P2

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By R.J. Rutherford | Boring Date August 18, 1985 |
| Boring No. M-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5564892.896 m | Easting 18847.365 m | Elevation 1092.687 m (Ground) |

SAMPLE TYPES
- AS Auger sample
- WS Wash sample
- RC Rock core
- CR CRREL barrel
- SS Split spoon
- TO Thin wall open
- TP Thin wall piston

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

SSA (152 mm ø hole)

| Depth (m) | | Soil/Rock Description | Ice | Sample Type | Condition | Number | Other Tests | Piezometer Details |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | AS | ☒ | | steel casing | |
| 1 | damp | CI, light and dark brown, trace silt, stiff. | | AS | ☒ | | | |
| 2 | | | | AS | ☒ | | | |
| 3 | | Shale, grey-green, soft. | | | | | | |
| 4 | dry | | | AS | ☒ | | | |
| 5 | | CI, brown-grey, trace silt, hard, medium plasticity with layers of very hard CI. | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | AS | ☒ | | backfill | |
| 8 | | | | | | | | |
| 9 | | Shale, grey, hard. | | | | | | |
| | | CI, grey, trace silt, hard. | | | | | | |

NOTES:

**PITEAU ENGINEERING LTD**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 18, 1985 |
| Boring No. M-PI | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5564892.896 m | Easting 18847.365 m | Elevation 1092.687 m (Ground) |

**SAMPLE TYPES**

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

**SAMPLE CONDITION**

- ☒ Disturbed
- ▩ Fair
- ▨ Good
- ■ Lost

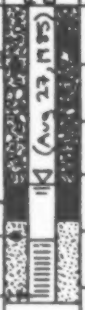
**TEST INFORMATION**

● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM
10 30 50 70 90

SSA (152 mm ø hole)

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | ICE | Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|---|
| 11 | ▨ | CI, grey, trace silt, hard. | | AS | ☒ | | backfill |
| 12 | ▧ | Shale, grey, hard. Possibly bedrock. | ▽ | AS<br>AS | ☒<br>☒ | $K = 1.1\times10^{-7}$ | bent seal<br>Frac sand & slough<br>screen |
| 13 | | End of Hole @ 12.65 m.<br>(Drill unable to penetrate) | | | | | |

PIEZOMETER DETAILS



NOTES:

JOB NO. 2097 BORING NO. M-PI

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 18, 1985 |
| Boring No. M-P2 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5564892.874 m | Easting 18845.697 m | Elevation 1092.697 m (Ground) |

SAMPLE TYPES

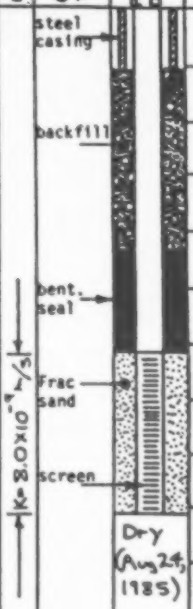
| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % ⊕ PLASTIC LIM. LIQUID LIM. 10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION<br>SSA (152 mm Ø hole) | ICE | Type | Condition |
|---|---|---|---|---|---|
| | ▨ | | | AS | ☒ |
| 1 | ▨ | – damp  CI, light and dark brown, trace silt, stiff. | | AS | ☒ |
| 2 | ▨ | | | | |
| | ▨ | | | AS | ☒ |
| 3 | ▨ | Shale, grey-green, soft. | | | |
| 4 | ▨ | CI, brown-grey, trace silt, hard, medium plasticity, with layers of very hard CI.<br>– dry | | AS | ☒ |
| 5 | | End of Hole @ 4.57 m. | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |



NOTES:

JOB NO. 2097. BORING NO. M-P2.

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

Contract No. A85-2097
Boring No. N-P1
Northing 5558466.644 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 17575.896 m
Boring Date August 19, 1985
Contractor Allkind Drilling
Elevation 1095.375 m (Ground)

SAMPLE TYPES

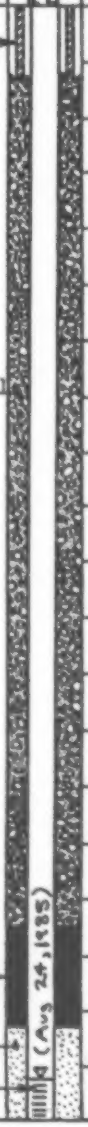
| | |
|---|---|
| AS | Auger sample |
| WS | Wash sample |
| RC | Rock core |
| CR | CRREL barrel |
| SS | Split spoon |
| TO | Thin wall open |
| TP | Thin wall piston |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % ⊙ PLASTIC LIM. LIQUID LIM.
10 30 50 70 90

| Depth | Symbol | SOIL/ROCK DESCRIPTION SSA (152 Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|
| | | OL, dark brown soil with organics. | | AS | ☒ | | steel casing | |
| 1<br>2 | | – moist<br>CL (till), light brown, some silt, stiff, low - medium plasticity, moist with sub-rounded erratics ≤ 2 cm | | AS | ☒ | | | |
| 3 | | GC, sub-rounded erratics, poorly sorted, dirty, ≤ 5 cm Ø. | | | | | backfill | |
| 4<br>5<br>6 | | – moist<br>CL (till), brown, and silt, stiff, moist with sub-rounded erratics and layers of hard, brown clay. | | AS | ☒ | | | |
| 7<br>8<br>9 | | – dry<br>CI (till), grey, trace silt, stiff-hard, medium plasticity, dry - moist, with sub-rounded erratics. | | AS | ☒ | X | bent. seal<br>Frac sand<br>screen | |



NOTES:

JOB NO. 2097 BORING NO. N-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By R.J. Rutherford | Boring Date August 19, 1985 |
| Boring No. N-P1 | Location Pine Coulee | Contractor Allking Drilling |
| Northing 5558466.644 m | Easting 17575.896 m | Elevation 1095.375 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted

SAMPLE HAMMER: wt. 140 lb drop 30 in

WEATHER

SAMPLE CONDITION

☒ Disturbed

▥ Fair

▨ Good

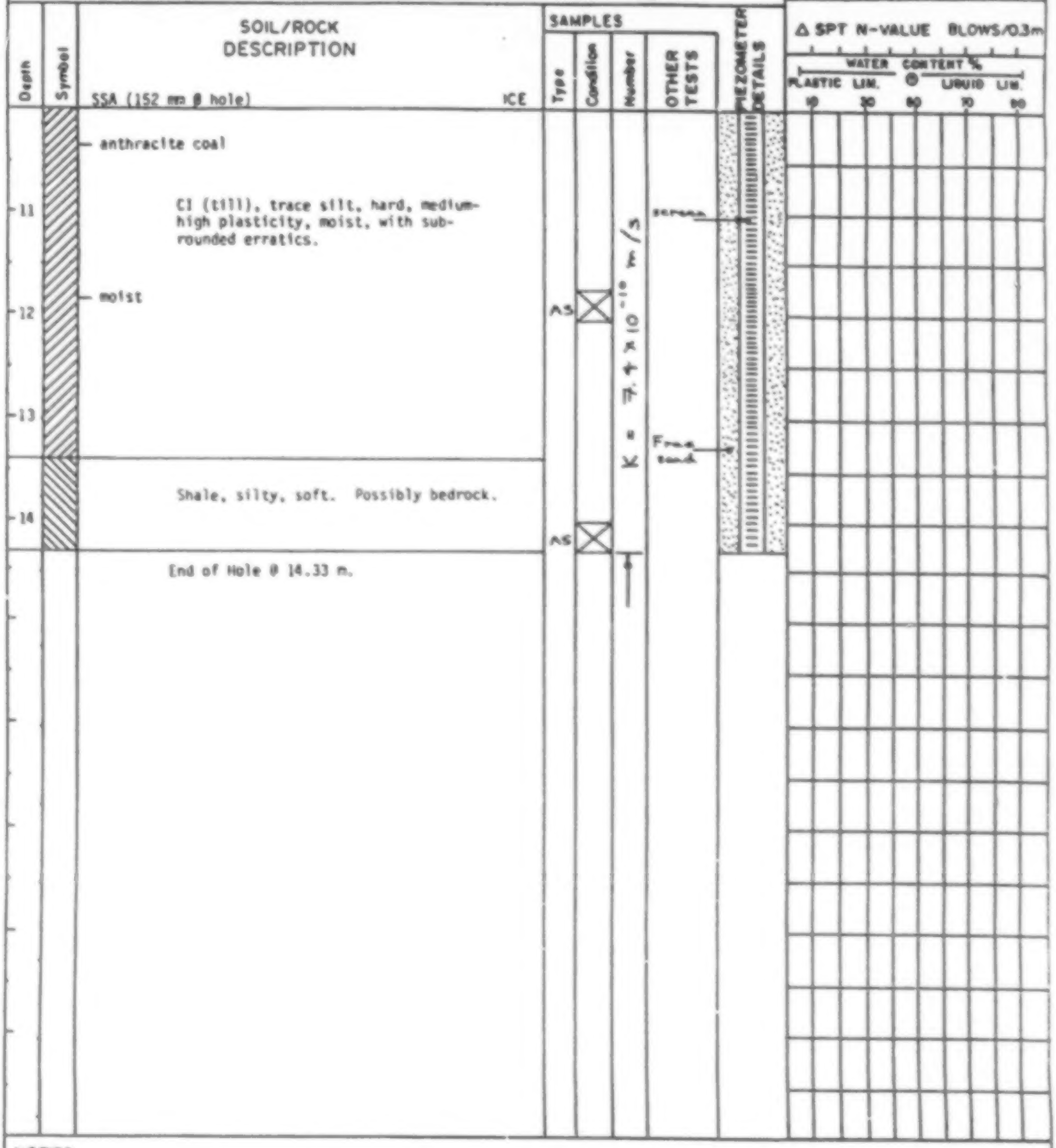
■ Lost

TEST INFORMATION

● PENETROMETER kN/m²

☐ UNCONFINED COMP STR kN/m²

△ SPT N-VALUE BLOWS/0.3m


SOIL/ROCK DESCRIPTION
Depth
Symbol
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
WATER CONTENT %
PLASTIC LIM.
LIQUID LIM.
10
30
50
70
90
11
12
13
14
screen
Free sand
K = 7.4 × 10⁻¹⁰ m/s
AS
AS

| Depth (m) | Soil/Rock Description | Type | Condition |
|---|---|---|---|
| | – anthracite coal | | |
| 11 | CI (till), trace silt, hard, medium-high plasticity, moist, with sub-rounded erratics. | | |
| | – moist | | |
| 12 | | AS | ☒ |
| 13 | | | |
| | Shale, silty, soft. Possibly bedrock. | | |
| 14 | | AS | ☒ |
| | End of Hole @ 14.33 m. | | |

Other tests: screen; Free sand

Number: K = 7.4 × 10⁻¹⁰ m/s

NOTES:

JOB NO. 2097 BORING NO. N-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. ABS-2097
Boring No. N-P2
Northing 5558468.244 m
Compiled By R.J. Rutherford
Location Pine Coulee
Easting 17575.916 m
Boring Date August 19, 1985
Contractor Allkind Drilling
Elevation 1095.364 m (Ground)

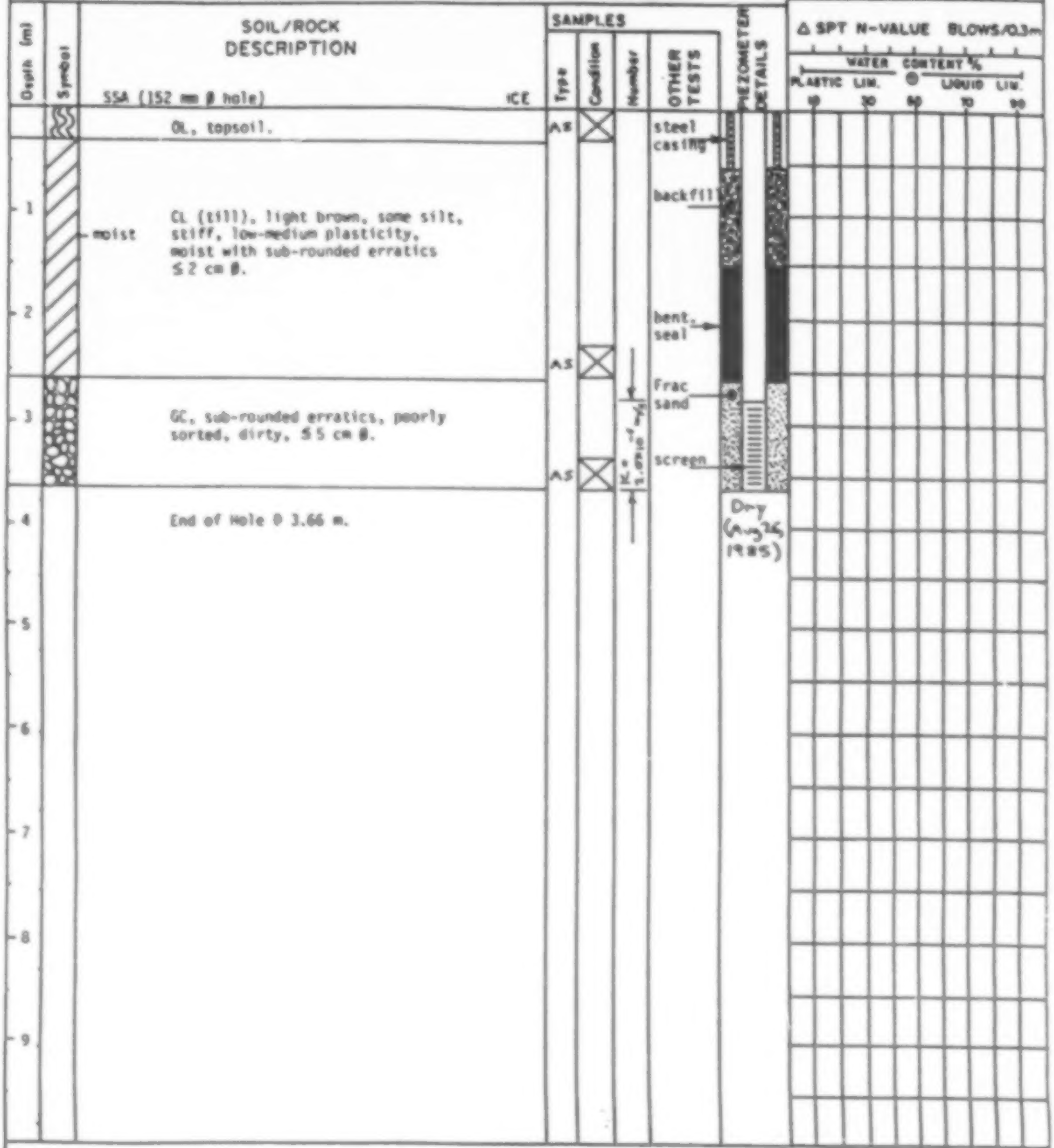
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▨ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER kN/m²
- ☐ UNCONFINED COMP STR kN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ● LIQUID LIM. — 10 30 50 70 90


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
1
2
3
4
5
6
7
8
9
steel casing
backfill
bent. seal
Frac sand
screen
$K = 1.0 \times 10^{-7}$ m/s
Dry (Aug 26, 1985)

| Depth (m) | Soil/Rock Description | Sample Type | Condition |
|---|---|---|---|
| 0 | OL, topsoil. | AS | ☒ |
| 0.3 | moist — CL (till), light brown, some silt, stiff, low-medium plasticity, moist with sub-rounded erratics ≤ 2 cm Ø. | AS | ☒ |
| 2.6 | GC, sub-rounded erratics, poorly sorted, dirty, ≤ 5 cm Ø. | AS | ☒ |
| 3.66 | End of Hole @ 3.66 m. | | |

NOTES:

JOB NO. 2097. BORING NO. N-P2.

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. ARS-2097 | Compiled By A.J. Rutherford | Boring Date August 19, 1985 |
| Boring No. O-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5558428.552 m | Easting 20655.704 m | Elevation 1054.680 m (Ground) |

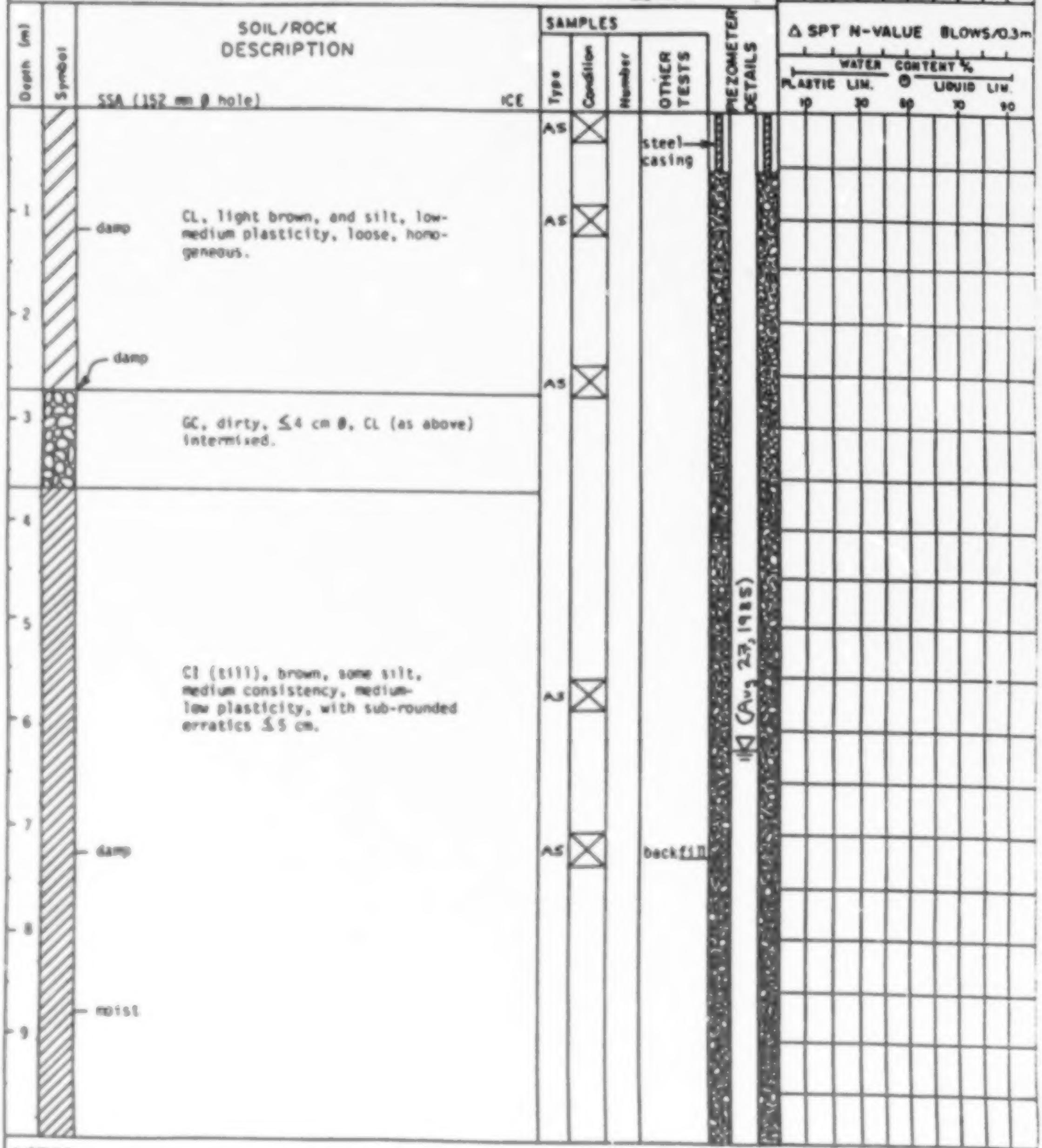
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
1
2
3
4
5
6
7
8
9
damp
damp
damp
moist
AS
AS
AS
AS
AS
steel casing
backfill
(Aug 27, 1985)

CL, light brown, and silt, low-medium plasticity, loose, homogeneous.

GC, dirty, ≤4 cm Ø, CL (as above) intermixed.

CI (till), brown, some silt, medium consistency, medium-low plasticity, with sub-rounded erratics ≤5 cm.

NOTES:

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GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

Contract No. A85-2097
Boring No. O-PI
Northing 5558428.552 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 20655.704 m
Boring Date August 19, 1985
Contractor Allkind Drilling
Elevation 1054.680 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

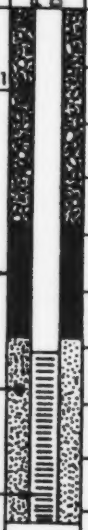
TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.
10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION<br>SSA (152 mm Ø hole) | ICE | SAMPLES Type | Condition | Number | OTHER TESTS |
|---|---|---|---|---|---|---|---|
| | | CI (till), brown, as above. | | AS | ☒ | | |
| 11 | | CI (till), grey, some silt, stiff, medium plasticity, with sub-rounded erratics. | | | | | backfill |
| 12 | very moist | | | AS | ☒ | | bent. seal |
| 13 | | | | AS | ☒ | K= 1.1 x 10⁻⁹ m/s | Frac sand |
| 14 | wet | | | AS | ☒ | | screen |
| 15 | | End of Hole @ 14.36 m. | | | | | |

PIEZOMETER DETAILS



NOTES:

JOB NO. 2097 BORING NO. O-PI

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 1

Contract No. ABS-2097
Boring No. O-P2
Northing 5558428.604 m

Compiled By R.J. Rutherford
Location Pine Coulee
Easting 20656.910 m

Boring Date August 20, 1985
Contractor Allkind Drilling
Elevation 1054.682 m (Ground)

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

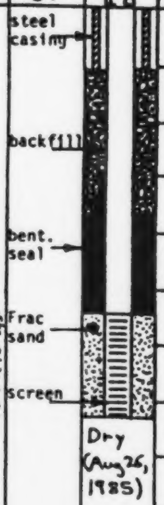
SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ○ LIQUID LIM
10 30 50 70 90

SSA (152 mm Ø hole)

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | ICE | Type | Condition | Number |
|---|---|---|---|---|---|---|
| 0 | ▨ | | | AS | ☒ | |
| 1 | | damp | | AS | ☒ | |
| | | CL, light brown, and silt, low-medium plasticity, loose, homogeneous. | | | | |
| 2 | | damp | | AS | ☒ | |
| 3 | | GC, dirty, ≤ 4 cm Ø. CL (as above) intermixed. | | AS | ☒ | |
| 4 | | End of Hole @ 3.66 m. | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |

$K = 3.3 \times 10^{-6}$ m/s



NOTES:

JOB NO. 2097. BORING NO. O-P2

| PITEAU ENGINEERING LTD.<br>GEOTECHNICAL CONSULTANTS | OFFICE REPORT ON SITE INVESTIGATION | Sheet 1 of 2 |
|---|---|---|

Contract No. A85-2097
Boring No. P-P1
Northing 5561649.623 m.
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 19208.156 m.
Boring Date August 20, 1985.
Contractor Alljkind Drilling
Elevation 1064.692 m (Ground).

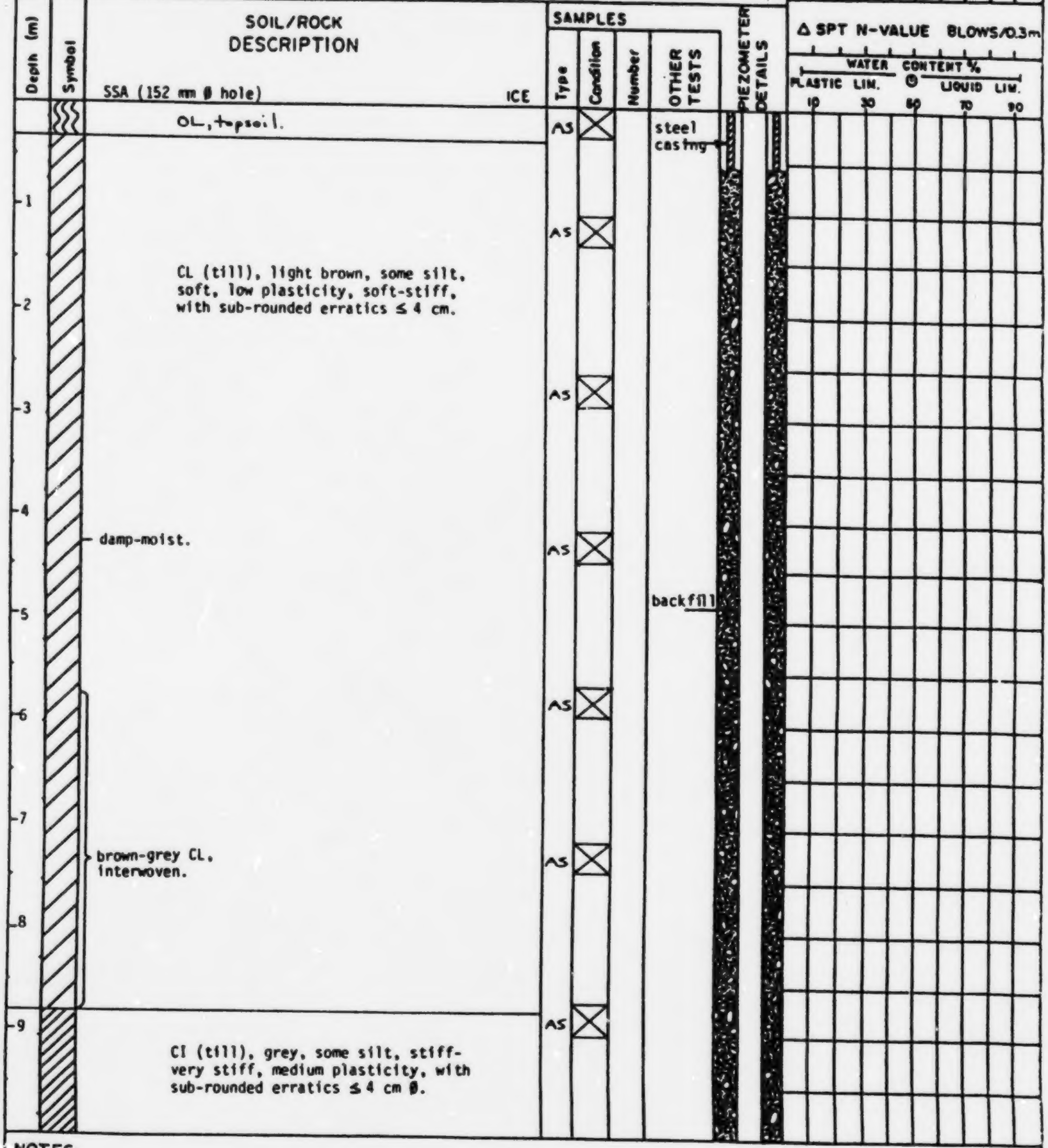
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % ⊖ PLASTIC LIM. LIQUID LIM.



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
ICE
10
30
50
70
90
1
2
3
4
5
6
7
8
9

SSA (152 mm ∅ hole)

OL, topsoil. — AS ☒ — steel casing

CL (till), light brown, some silt, soft, low plasticity, soft-stiff, with sub-rounded erratics ≤ 4 cm. — AS ☒ — AS ☒

- damp-moist. — AS ☒ — backfill

AS ☒

brown-grey CL, interwoven. — AS ☒

CI (till), grey, some silt, stiff-very stiff, medium plasticity, with sub-rounded erratics ≤ 4 cm ∅. — AS ☒

NOTES:

JOB NO. 2097 BORING NO. P-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

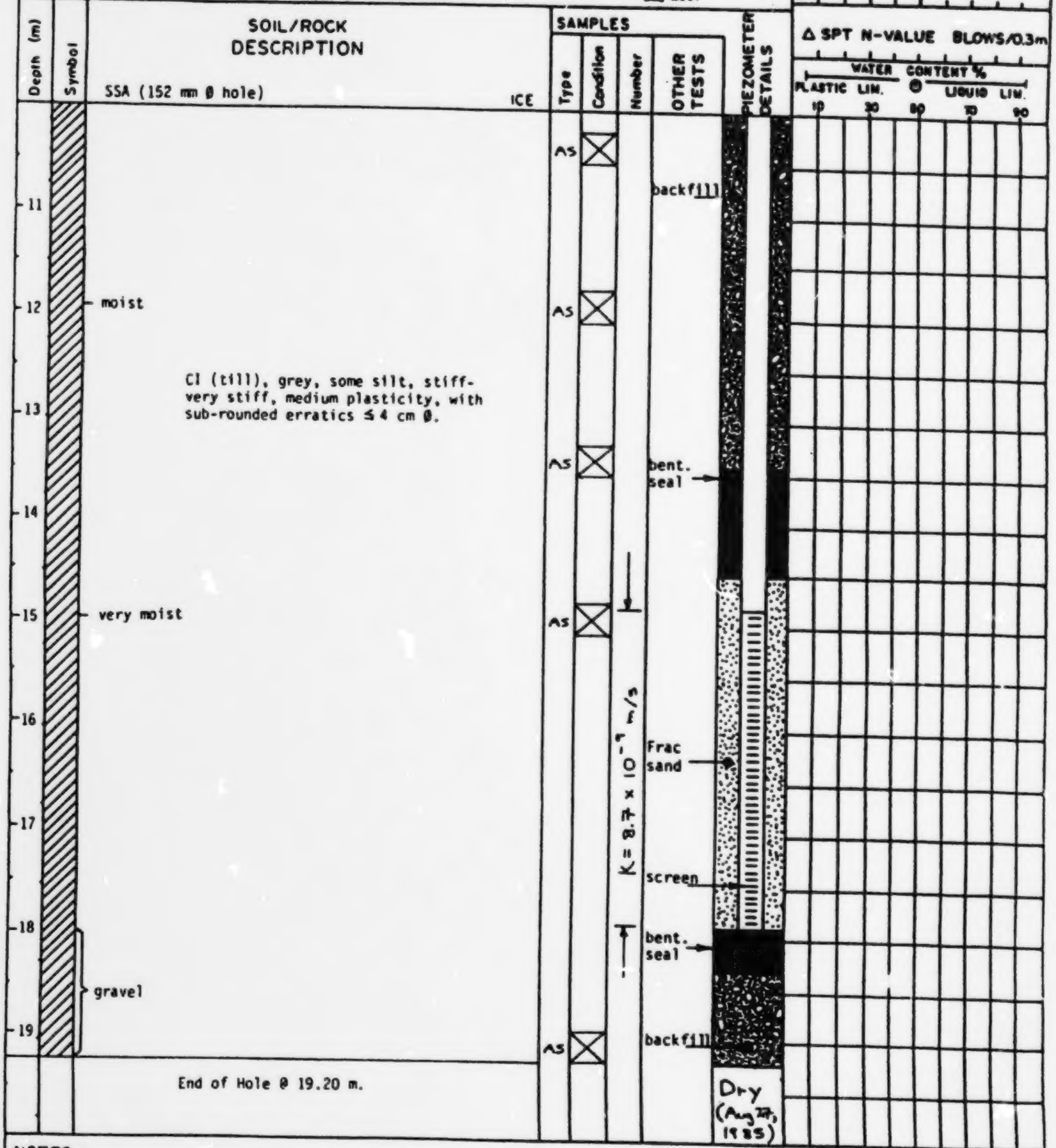
Contract No. A85-2097
Boring No. P-P1
Northing 5561649.623 m
Compiled By B.J. Rutherford
Location Pine Coulee
Easting 19208.156 m
Boring Date August 20, 1985
Contractor Allkind Drilling
Elevation 1064.692 m (Ground)

SAMPLE TYPES
AS Auger sample
WS Wash sample
RC Rock core
CR CRREL barrel
SS Split spoon
TO Thin wall open
TP Thin wall piston

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊖ LIQUID LIM.



Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm Ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
11
12
13
14
15
16
17
18
19
AS
AS
AS
AS
AS
backfill
bent. seal
Frac sand
screen
bent. seal
backfill
K = 8.7 × 10⁻⁹ m/s
Dry (Aug 27, 1985)

- moist

Cl (till), grey, some silt, stiff-very stiff, medium plasticity, with sub-rounded erratics ≤ 4 cm Ø.

- very moist

gravel

End of Hole @ 19.20 m.

NOTES:

JOB NO. 2097. BORING NO. P-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 22, 1985 |
| Boring No. Q-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561698.632 m | Easting 17569.922 m | Elevation 1043.790 m (Ground) |

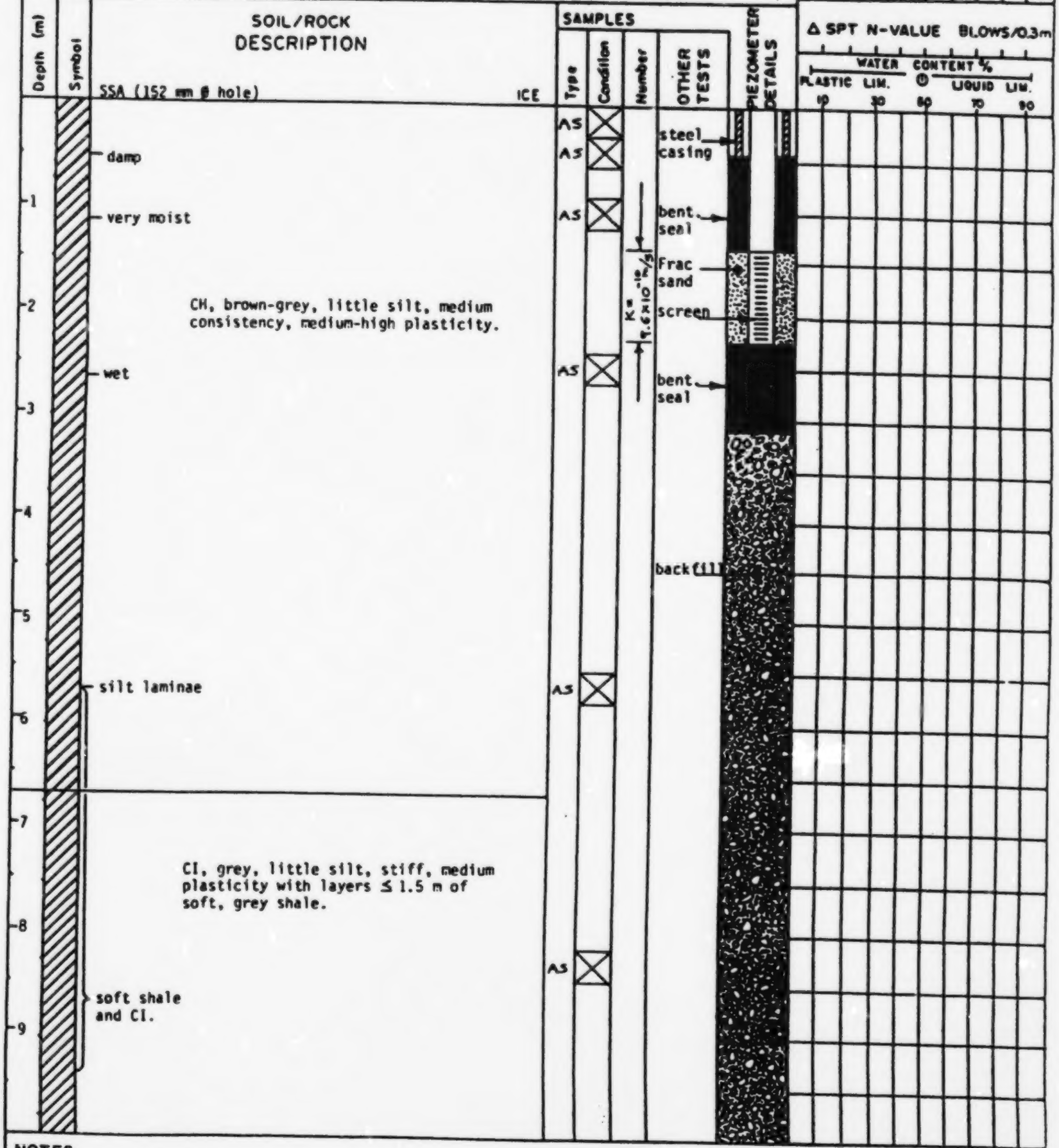
SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %
PLASTIC LIM. ⊙ LIQUID LIM.


Depth (m)
Symbol
SOIL/ROCK DESCRIPTION
SSA (152 mm ø hole)
ICE
SAMPLES
Type
Condition
Number
OTHER TESTS
PIEZOMETER DETAILS
10
30
50
70
90
1
2
3
4
5
6
7
8
9
damp
very moist
wet
silt laminae
soft shale and CI.
AS
AS
AS
AS
AS
AS
$K = 7.6\times10^{-10}$ m/s
steel casing
bent. seal
Frac sand
screen
bent. seal
backfill

CH, brown-grey, little silt, medium consistency, medium-high plasticity.

CI, grey, little silt, stiff, medium plasticity with layers ≤ 1.5 m of soft, grey shale.

NOTES:

JOB NO. 2097 BORING NO. Q-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

| | | |
|---|---|---|
| Contract No. A85-1097 | Compiled By B.J. Rutherford | Boring Date August 22, 1985 |
| Boring No. Q-P1 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561698.632 m | Easting 17569.922 m | Elevation 1043.790 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER kN/m²
☐ UNCONFINED COMP STR kN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT %: PLASTIC LIM. — ⊙ — LIQUID LIM.
10 30 50 70 90

SSA (152 mm ∅ hole)

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION | ICE | SAMPLES Type | SAMPLES Condition | SAMPLES Number | OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|
| | ▨ | – wet | | AS | ☒ | | | |
| 11 | ▨ | Cl, grey, little silt, stiff, medium plasticity with layers ≤ 1.5 m of soft, grey shale.<br>soft shale and layers (2.5-5.0cm) of Cl. | | | | | backfill | backfill |
| | ▨ | | | AS | ☒ | | | |
| 12 | | End of Hole @ 11.89 m. | | | | | | Dry (Aug 26, 1985) |

NOTES:

JOB NO. 2097 BORING NO. Q-P1

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

# OFFICE REPORT ON SITE INVESTIGATION

Sheet 1 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 23, 1985 |
| Boring No. Q-P2 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561700.820 m | Easting 17569.856 m | Elevation 1043.717 m (Ground) |

SAMPLE TYPES

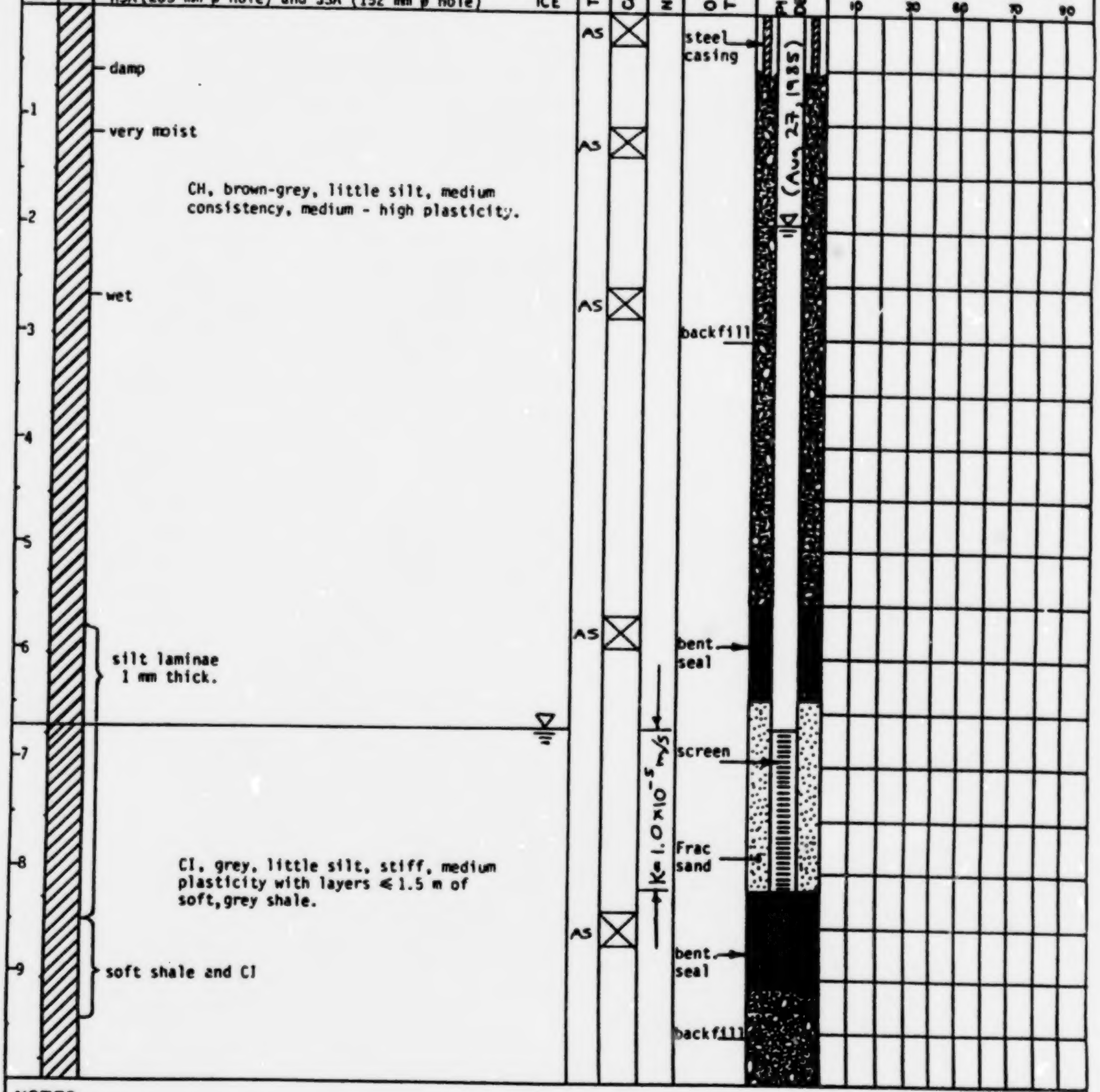
| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61-Truck Mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
☒ Disturbed
▥ Fair
▨ Good
■ Lost

TEST INFORMATION
● PENETROMETER KN/m²
☐ UNCONFINED COMP STR KN/m²
△ SPT N-VALUE BLOWS/0.3m
WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM.
10 30 50 70 90

| Depth (m) | Symbol | SOIL/ROCK DESCRIPTION<br>HSA (203 mm Ø hole) and SSA (152 mm Ø hole) | ICE | SAMPLES Type | SAMPLES Condition | SAMPLES Number | SAMPLES OTHER TESTS | PIEZOMETER DETAILS |
|---|---|---|---|---|---|---|---|---|



1
2
3
4
5
6
7
8
9
damp
very moist
wet
silt laminae 1 mm thick.
soft shale and CI
AS
AS
AS
AS
AS
steel casing
backfill
bent. seal
screen
Frac sand
bent. seal
backfill
(Aug 27, 1985)
K= 1.0x10⁻⁵ m/s

CH, brown-grey, little silt, medium consistency, medium - high plasticity.

CI, grey, little silt, stiff, medium plasticity with layers ≤ 1.5 m of soft, grey shale.

NOTES:

JOB NO. 2097. BORING NO. Q-P2.

**PITEAU ENGINEERING LTD.**
GEOTECHNICAL CONSULTANTS

## OFFICE REPORT ON SITE INVESTIGATION

Sheet 2 of 2

| | | |
|---|---|---|
| Contract No. A85-2097 | Compiled By B.J. Rutherford | Boring Date August 23, 1985 |
| Boring No. Q-P2 | Location Pine Coulee | Contractor Allkind Drilling |
| Northing 5561700.820 m | Easting 17569,856 m | ~~Elevation~~: 1043,717 m (Ground) |

SAMPLE TYPES

| | | | |
|---|---|---|---|
| AS | Auger sample | TO | Thin wall open |
| WS | Wash sample | TP | Thin wall piston |
| RC | Rock core | | |
| CR | CRREL barrel | | |
| SS | Split spoon | | |

TYPE OF RIG B61 - truck mounted
SAMPLE HAMMER: wt. 140 lb drop 30 in
WEATHER

SAMPLE CONDITION
- ☒ Disturbed
- ▥ Fair
- ▨ Good
- ■ Lost

TEST INFORMATION
- ● PENETROMETER KN/m²
- ☐ UNCONFINED COMP STR KN/m²
- △ SPT N-VALUE BLOWS/0.3m
- WATER CONTENT % — PLASTIC LIM. ⊙ LIQUID LIM. — 10 30 50 70 90

SOIL/ROCK DESCRIPTION — HSA (203 mm ø hole) and SSA (152 mm ø hole)

| Depth (m) | Symbol | Soil/Rock Description | ICE | Type | Condition | Number | Other Tests | Piezometer Details |
|---|---|---|---|---|---|---|---|---|
| | ▨ | wet | | | | | | |
| 11–12 | ▨ | soft shale and layers (2.5 - 5.0cm) of CI. | | | | | | |
| 12 | ▨ | | | AS | ☒ | | | |
| 13 | ▨ | CI, grey, little silt, hard, medium plasticity with layers ≤ 2 m of soft-medium hardness, grey (-green) shale and siltstone.(interbedded with CI). | | | | | | |
| 14 | ▨ | | | | | | backfill | |
| 15 | ▨ | | | AS | ☒ | | | |
| 15–16 | ▨ | medium hardness shale and siltstone. | | | | | | |
| 17 | ▨ | | | | | | | |
| 18 | ▨ | | | AS | ☒ | | | |
| 18–19.5 | ▨ | medium hardness shale with layers (2.5 - 5.0cm) of CI. | | | | | | |
| 19.5 | ▨ | | | AS | ☒ | | | |
| | | End of Hole @ 19.5 m. | | | | | | |

NOTES:

JOB NO. 2097 BORING NO. Q-P2

# WATER LEVEL MEASUREMENTS AND HYDRAULIC CONDUCTIVITY TESTS

(Measurements Relative to Top of PVC Pipe)

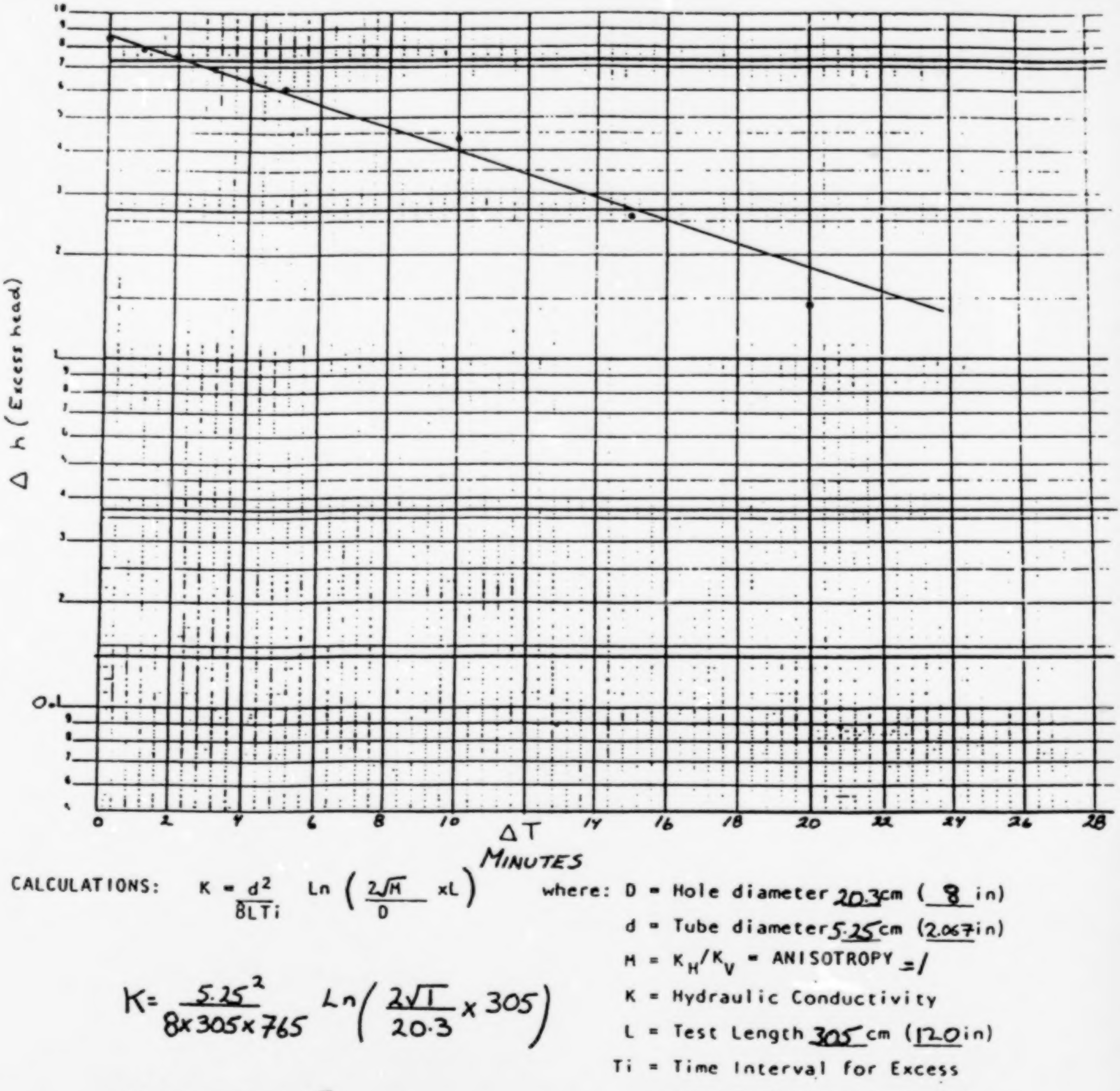
PA-6

Permeability Test Sheet for Test No A P-1 (Bail Test)

Sheet 1 of 2

Test Interval 17.53 to 20.57 (metres)

57.5 to 67.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ Ln\left(\frac{2\sqrt{M}}{D} xL\right)$

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold

= 765 seconds

$$K = \frac{5.25^2}{8 \times 305 \times 765} \ Ln\left(\frac{2\sqrt{1}}{20.3} \times 305\right)$$

$K = 5.0 \times 10^{-5}$ cm/sec

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (A-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug23 14:00 | | 5.86 m | | |
| 24 09:46 | | 5.89 | | |
| 10:20 | | 13.62 | | Developed piezometer ⇒ dirty water |
| 10:32 | | 11.33 | | |
| 10:49 | | 15.75 | | Developed |
| 11:16 | | 16.56 | | Developed |
| 14:24 | | 17.05 | | Developed |
| 25 09:10 | | 5.59 | | |
| 11:36 | | 13.75 | | |
| 29 09:40 | | 5.60 | | Datum (for hydraulic cond. test) |
| 10:00 | 0 min | 14.05 | 8.45 m | Rising Head (Bail) Test. |
| | 1 | 13.47 | 7.87 | |
| | 2 | 13.01 | 7.41 | |
| | 3 | 12.48 | 6.88 | |
| | 4 | 12.05 | 6.45 | |
| | 5 | 11.60 | 6.00 | |
| | 10 | 9.63 | 4.03 | |
| | 15 | 8.17 | 2.57 | |
| | 20 | 7.05 | 1.45 | |
| | 30 | 5.78 | 0.18 | |
| | 50 | 5.63 | 0.03 | |
| | 70 | 5.63 | 0.03 | |
| | 85 | 5.63 | 0.03 | |
| 14:55 | 295 | 5.62 | 0.02 | |
| | 375 | 5.61 | 0.01 | |
| 30 08:55 | 1375 | 5.60 | 0.00 | |

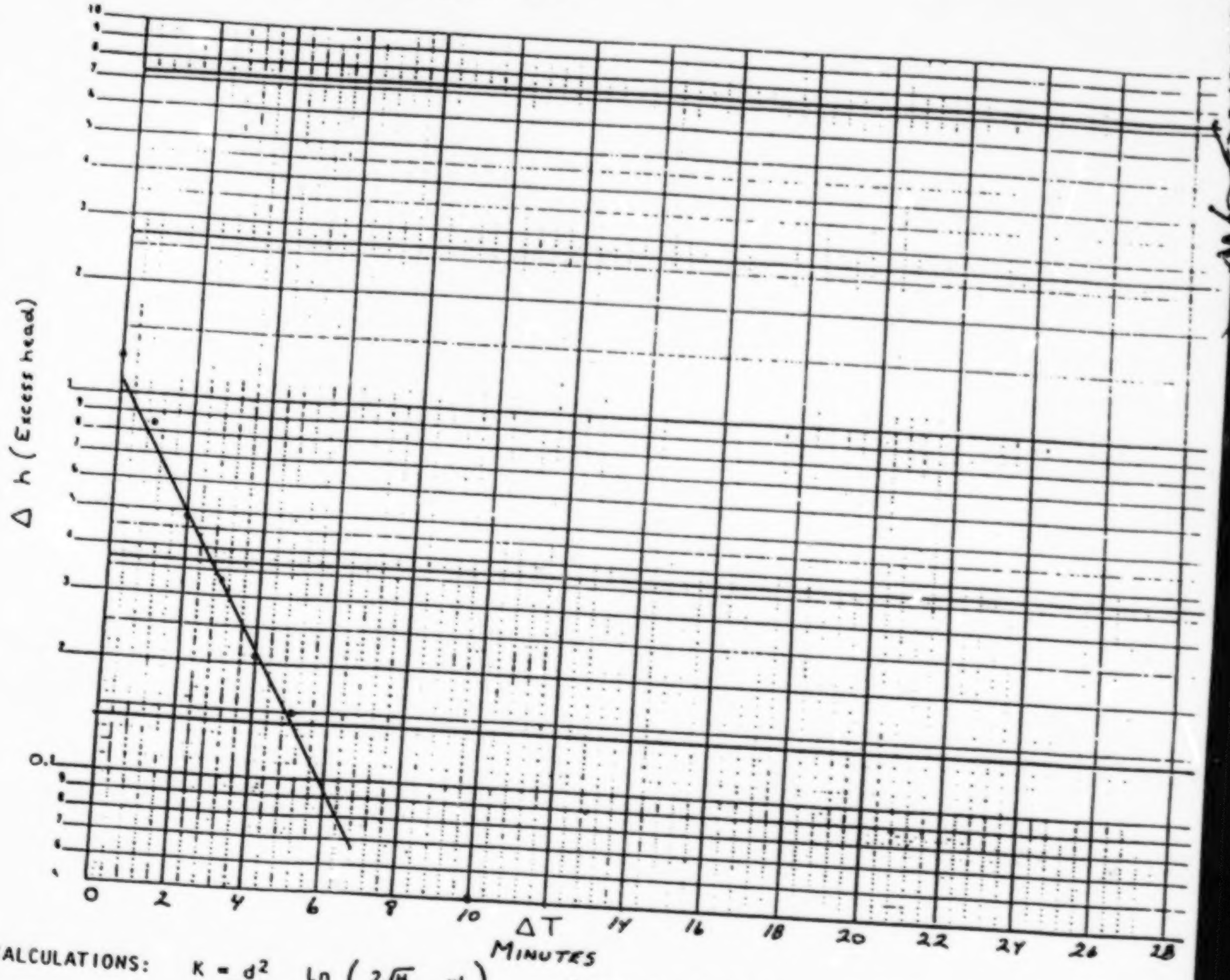
PA-6

Permeability Test Sheet for Test No A P-2 (Bail Test)

Sheet 1 of 2

Test Interval 13.56 to 15.09 (metres)

44.5 to 49.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ln\left(\frac{2\sqrt{H}}{D} xL\right)$

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

$H = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head (h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 146 seconds

$$K = \frac{5.25^2}{8 \times 152 \times 146} \ln\left(\frac{2\sqrt{1}}{20.3} \times 152\right)$$

$$K = 4.2 \times 10^{-4} \text{ cm/sec}$$

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

## Pine Coulee (A-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug23 14:02 | | 6.20 m | | |
| 24 9:47 | | 6.20 | | |
| 10:30 | | 9.53 | | Developed piezometer ⇒ dirty water |
| 10:43 | | 6.50 | | |
| 10:49 | | 6.47 | | |
| 14:28 | | 10.34 | | Developed |
| 25 9:15 | | 6.20 | | |
| 11:21 | | 10.20 | | Developed |
| 29 9:40 | | 6.20 | | Datum (for hydraulic cond. test) |
| 10:25 | 0 min | 7.47 | 1.27m | Rising Head (Bail) Test. |
| | 1 | 7.03 | 0.83 | |
| | 2 | 6.68 | 0.48 | |
| | 3 | 6.53 | 0.33 | |
| | 4 | 6.41 | 0.21 | |
| | 5 | 6.35 | 0.15 | |
| | 10 | 6.25 | 0.05 | |
| | 15 | 6.24 | 0.04 | |
| | 20 | 6.23 | 0.03 | |
| | 30 | 6.23 | 0.03 | |
| | 35 | 6.23 | 0.03 | |
| | 60 | 6.23 | 0.03 | |
| | 270 | 6.22 | 0.02 | |
| | 350 | 6.21 | 0.01 | |
| 30 8:55 | 1350 | 6.20 | 0.00 | |

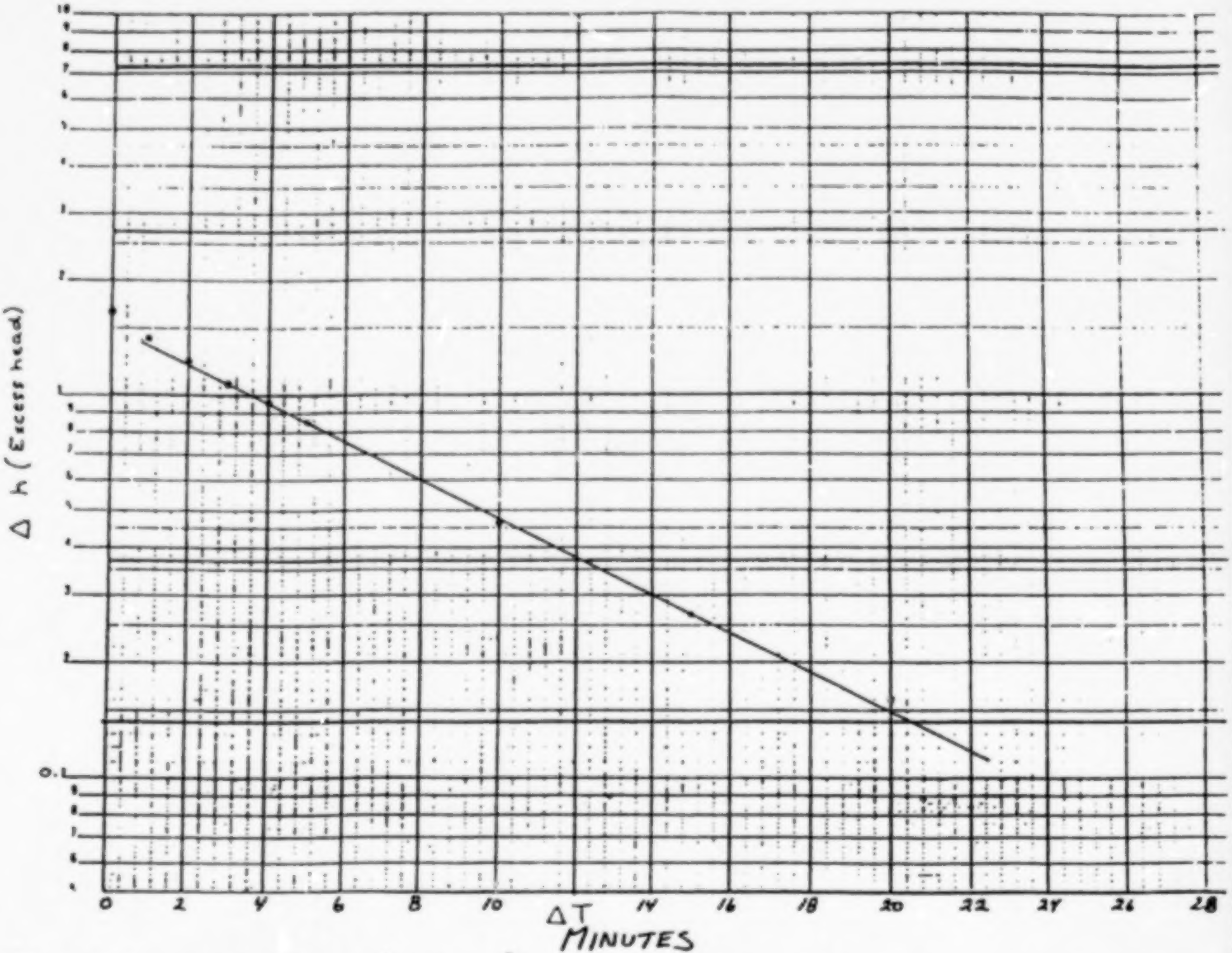
PA-6

**Permeability Test Sheet for Test No** A P-3 (Bail Test)

Sheet 1 of 2

Test Interval 5.79 to 6.71 (metres)

19 to 22 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ Ln \left( \frac{2\sqrt{M}}{D} xL \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 514} \ Ln \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$$K = 1.3 \times 10^{-4} \text{ cm/sec}$$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold

514 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (A-P3)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 14:10 | | 5.27m | | |
| 24 9:50 | | 5.27 | | |
| 10:00 | | 5.87 | | Developed piezometer ⇒ dirty water |
| 25 9:16 | | 5.27 | | |
| 29 9:40 | | 5.27 | | Datum (For hydraulic cond. test). |
| 11:00 | 0min | 6.94 | 1.67m | Rising Head (Bail) Test. |
| | 1 | 6.67 | 1.40 | |
| | 2 | 6.50 | 1.23 | |
| | 3 | 6.36 | 1.09 | |
| | 4 | 6.23 | 0.96 | |
| | 5 | 6.13 | 0.86 | |
| | 10 | 5.74 | 0.47 | |
| | 15 | 5.54 | 0.27 | |
| | 20 | 5.43 | 0.16 | |
| | 30 | 5.33 | 0.06 | |
| | 40 | 5.29 | 0.02 | |
| | 235 | 5.27 | 0.00 | |
| | 315 | 5.26 | — | |
| 30 9:00 | 1320 | 5.26 | — | |

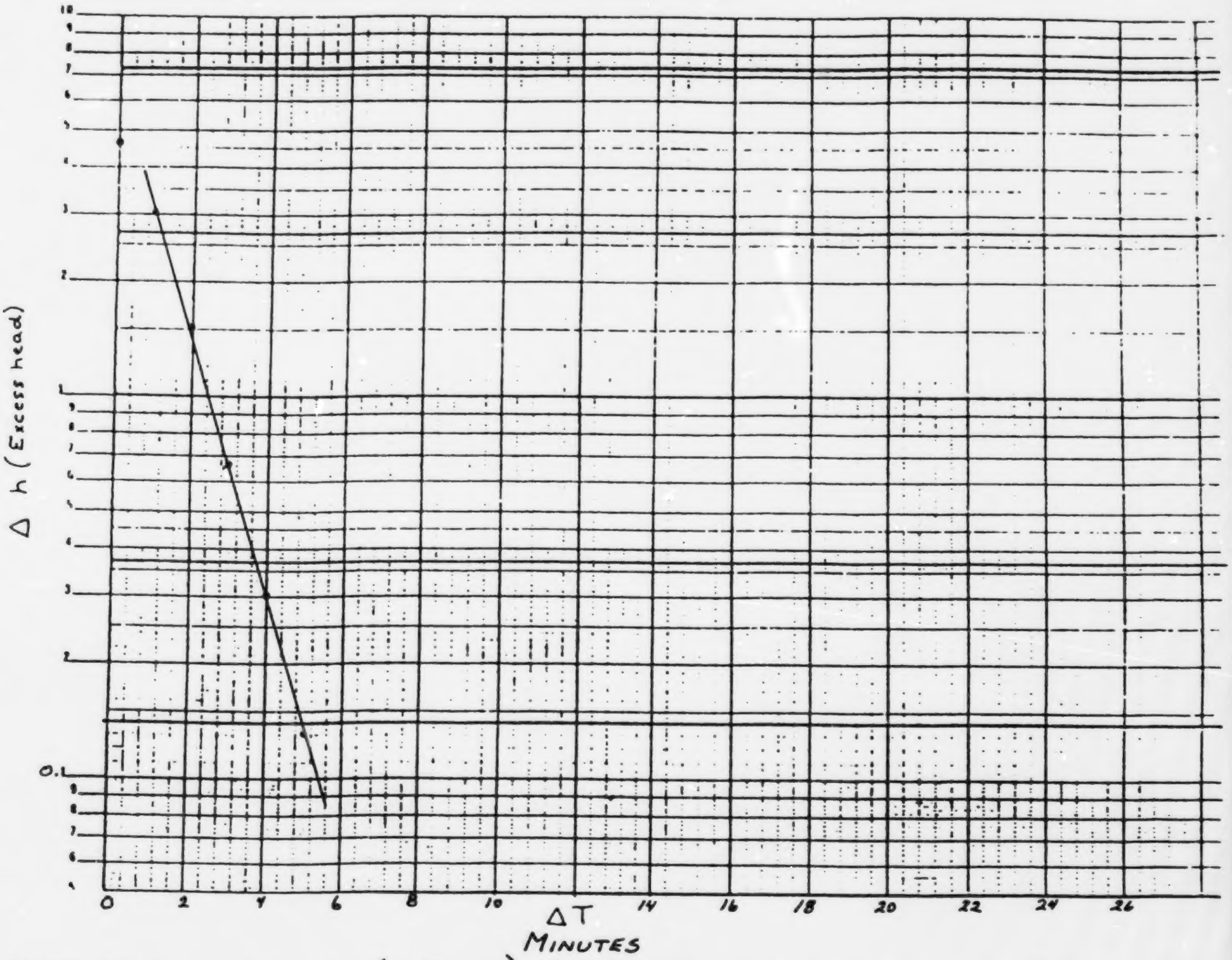
PA-6

**Permeability Test Sheet for Test No** B P-1 (Bail Test)

Sheet 1 of 2

Test Interval 14.33 to 17.37 (metres)

47 to 57 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \, Ln\left(\frac{2\sqrt{M}}{D} \times L\right)$

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold

78 seconds

$$K = \frac{5.25^2}{8 \times 305 \times 78} Ln\left(\frac{2\sqrt{1}}{20.3} \times 305\right)$$

$K = 4.9 \times 10^{-4}$ cm/sec

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

## Pine Coulee (B-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 14:26 | | 6.66 m | | |
| 24 11:41 | | 6.65 | | |
| 11:48 | | 12.01 | | Developed piezometer ⇒ dirty water |
| 11:53 | | 10.20 | | |
| 12:00 | | 10.21 | | Developed |
| 25 10:30 | | 6.64 | | |
| 11:08 | | 10.23 | | Developed |
| 29 12:30 | | 6.66 | | Datum (for hydraulic cond test) |
| 12:45 | 0 min | 11.28 | 4.62 m | Rising Head (Bail) Test. |
| | 1 | 9.67 | 3.01 | |
| | 2 | 8.17 | 1.51 | |
| | 3 | 7.33 | 0.67 | |
| | 4 | 6.96 | 0.30 | |
| | 5 | 6.79 | 0.13 | |
| | 10 | 6.72 | 0.06 | |
| | 15 | 6.70 | 0.04 | |
| | 20 | 6.69 | 0.03 | |
| | 30 | 6.69 | 0.03 | |
| | 50 | 6.68 | 0.02 | |
| | 120 | 6.67 | 0.01 | |
| | 200 | 6.66 | 0.00 | |
| 30 8:40 | 1195 | 6.63 | — | |

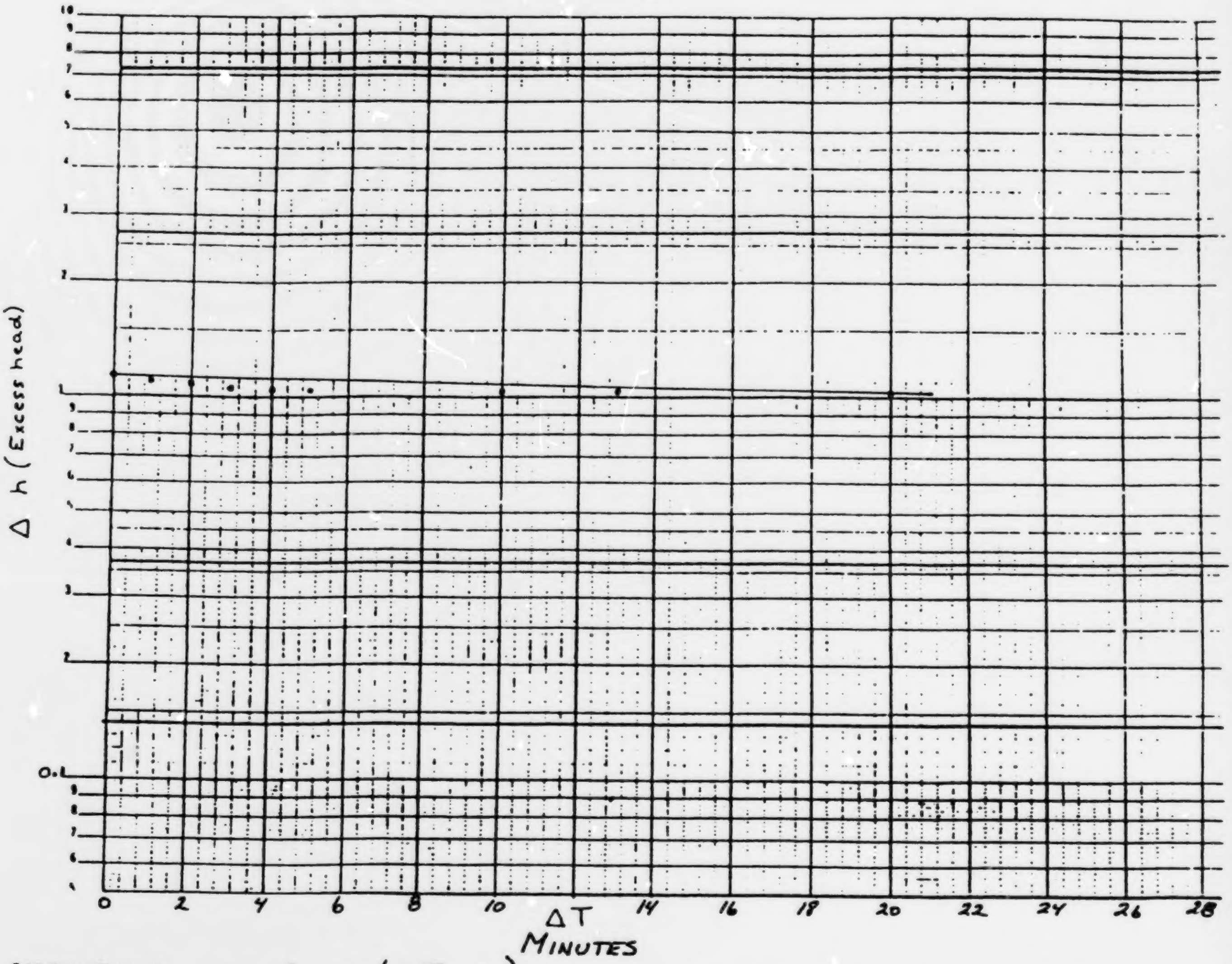
PA-6

Permeability Test Sheet for Test No B P-2 (Bail Test)

Sheet 1 of 2

Test Interval 4.57 to 7.62 (metres)

15 to 25 (feet)



CALCULATIONS: $K = \frac{d^2}{8LT_i} \ln\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{5.25^2}{8\times305\times222{,}147} \ln\left(\frac{2\sqrt{1}}{15.2}\times 305\right)$$

$$K = 1.9\times10^{-7} \text{ cm/sec}$$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 222,147 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (B - P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 14:30 | | 6.19m | | |
| 24 11:42 | | 6.19 | | |
| 11:51 | | —— | | Attempted to develop with $N_2$ purge |
| 25 10:29 | | 6.18 | | ⇒ developed by bailing |
| 29 12:30 | | 6.19 | | Datum (For hydraulic cond. test). |
| 13:05 | 0 min | 7.33 | 1.14m | Rising Head (Bail) Test. |
| | 1 | 7.30 | 1.11 | ⇒ bailed out clean water |
| | 2 | 7.27 | 1.08 | |
| | 3 | 7.26 | 1.07 | |
| | 4 | 7.26 | 1.07 | |
| | 5 | 7.25 | 1.06 | |
| | 10 | 7.25 | 1.06 | |
| | 15 | 7.24 | 1.05 | |
| | 20 | 7.23 | 1.04 | |
| | 30 | 7.22 | 1.03 | |
| | 100 | 7.19 | 1.00 | |
| | 180 | 7.17 | 0.98 | |
| 30 8:40 | 1175 | 7.02 | 0.83 | |

1/1

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (C-P1)

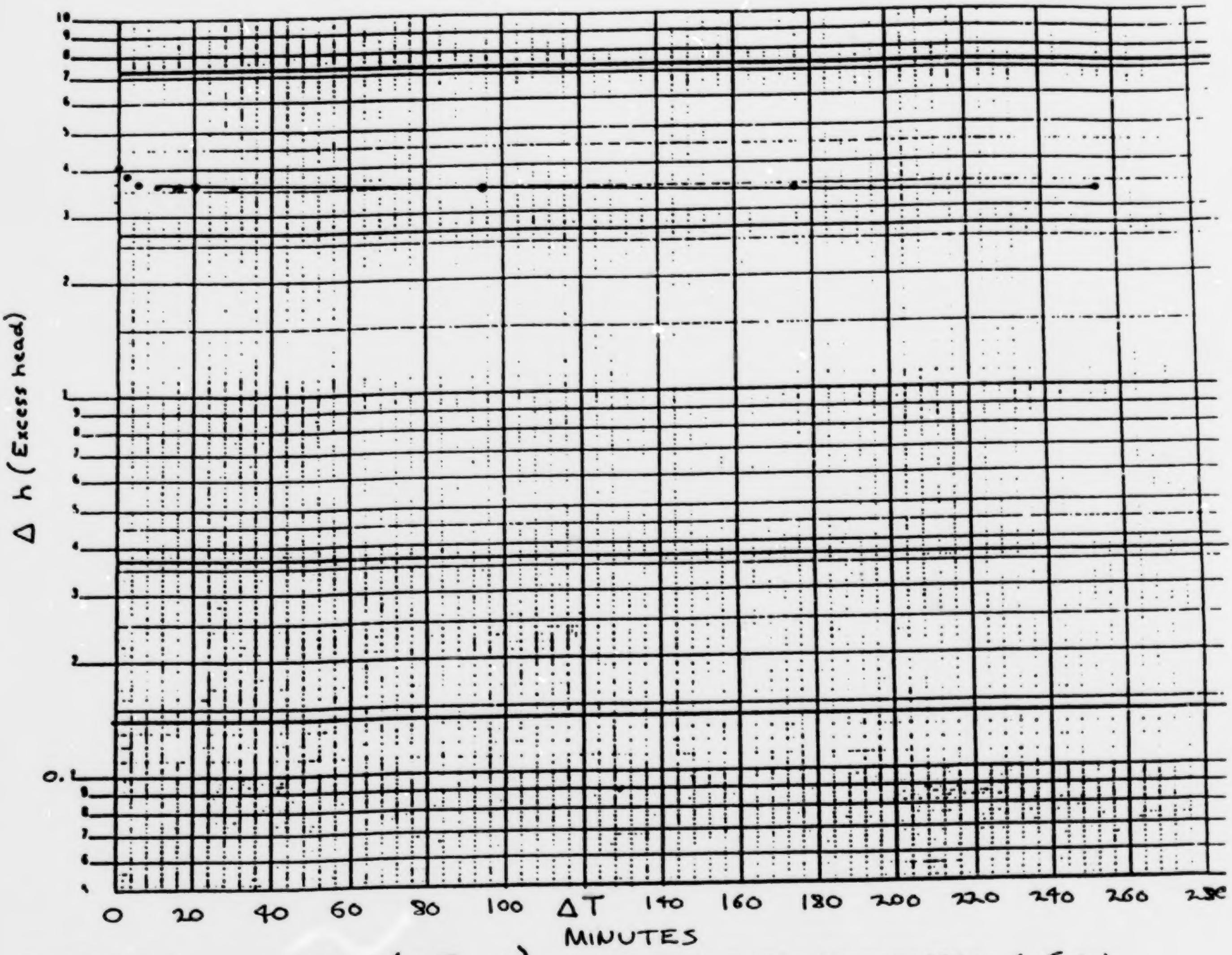
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug23 14:17 | | 5.89 m | | Clean water at top. |
| 24 13:30 | | 5.89 | | |
| 13:35 | | 6.20 | | Attempted to develop with $N_2$ purge |
| 14:13 | | 6.55 | | Developed piezometer ⇒ dirty water |
| 25 10:10 | | 6.55 | | |
| 10:25 | | 6.55 | | Attempted to develop ⇒ insufficient water |
| 29 11:50 | | 6.55 | | Attempted to develop |
| 12:00 | | 5.93 | | ⇒ piezometer is not functional |
| 30 08:35 | | 5.93 | | due to clay |

PA-6

**Permeability Test Sheet for Test No** C P-2 (Slug Test) **Sheet** 1 **of** 2

**Test Interval** 3.96 **to** 5.49 **(metres)**

13 **to** 18 **(feet)**



**CALCULATIONS:** $K = \frac{d^2}{8LTi} \ln\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{5.25^2}{8 \times 152 \times 102{,}900} \ln\left(\frac{2\sqrt{1}}{15.2} \times 152\right)$$

$K = 6.6 \times 10^{-7}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 102,900 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

## Pine Coulee (C-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 14:20 | | Dry | | |
| 24 13:25 | | Dry | | |
| 29 11:50 | | Dry | | Datum = 5.89 m |
| 11:55 | 0 min | 1.84 m | 4.05 m | Falling Head (Slug) Test |
| | 1 | 1.97 | 3.92 | |
| | 2 | 2.05 | 3.84 | |
| | 3 | 2.11 | 3.78 | |
| | 4 | 2.16 | 3.73 | |
| | 5 | 2.18 | 3.71 | |
| | 10 | 2.25 | 3.64 | |
| | 15 | 2.27 | 3.62 | |
| | 20 | 2.28 | 3.61 | |
| | 30 | 2.30 | 3.59 | |
| | 95 | 2.39 | 3.50 | |
| | 175 | 2.50 | 3.39 | |
| | 255 | 2.58 | 3.31 | |
| 30 8:35 | 1240 | 3.16 | 2.73 | |

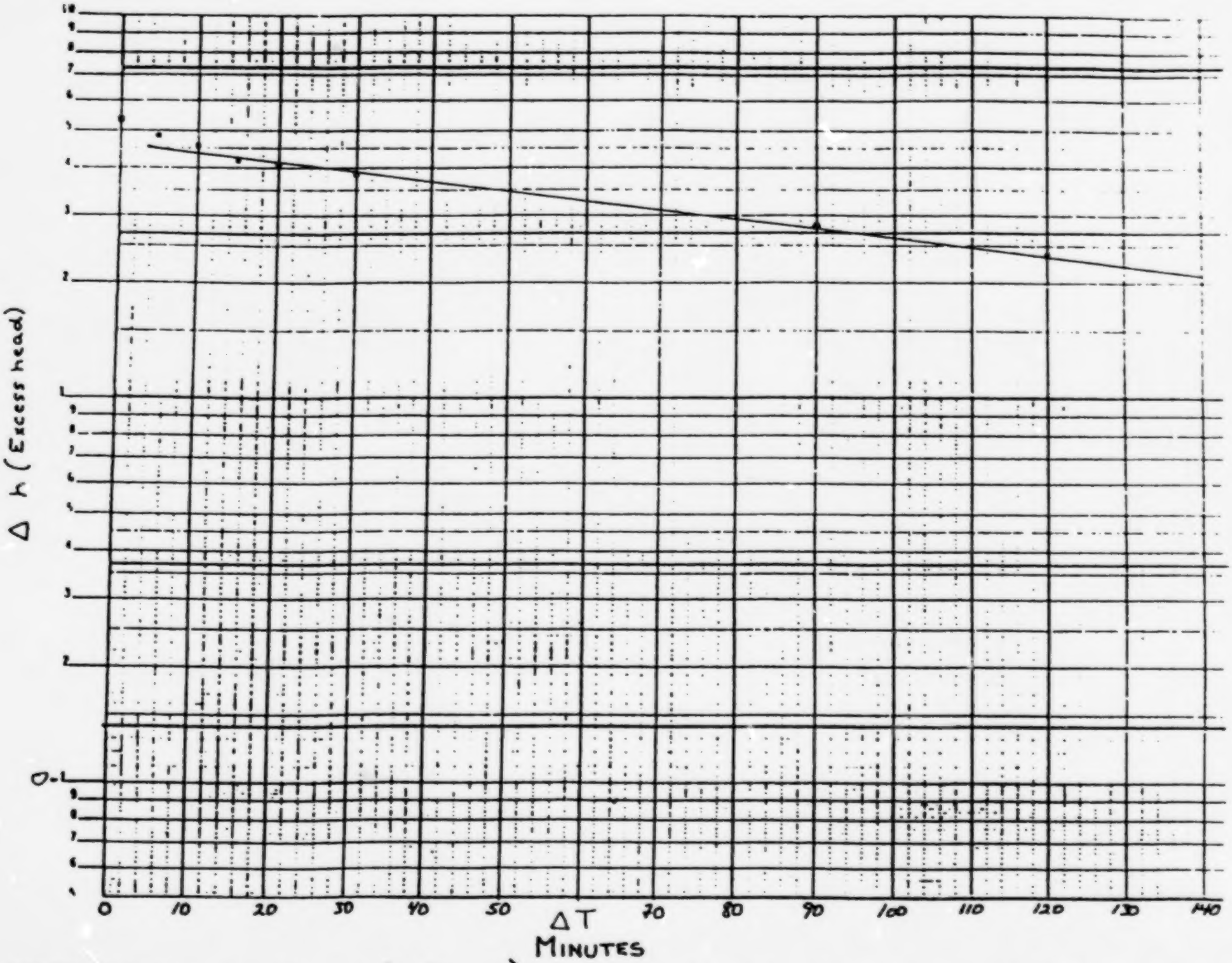
PA-6

Permeability Test Sheet for Test No D P-1 (Bail Test)

Sheet 1 of 2

Test Interval 10.21 to 11.73 (metres)

33.5 to 38.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln}\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{(5.25)^2}{8 \times 152 \times 9{,}105} \text{Ln}\left(\frac{2\sqrt{1}}{20.3} \times 152\right)$$

K= 6.7 X $10^{-6}$ cm/sec

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

9,105 seconds

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (D-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 14:38 | | 6.31m | | |
| 24 13:50 | | 6.32 | | |
| 14:00 | | 7.04 | | Developed piezometer ⇒ clean water |
| 25 10:46 | | 7.02 | | |
| 10:52 | | 8.51 | | Developed piezometer ⇒ dirty water |
| 29 13:40 | | 6.35 | | Datum (for hydraulic cond. test) |
| 14:00 | 0min | 11.62 | 5.27m | Rising Head (Bail) Test. |
| | 1 | 11.57 | 5.22 | |
| | 2 | 11.48 | 5.13 | |
| | 3 | 11.40 | 5.05 | |
| | 4 | 11.34 | 4.99 | |
| | 5 | 11.26 | 4.91 | |
| | 10 | 10.90 | 4.55 | |
| | 15 | 10.64 | 4.29 | |
| | 20 | 10.53 | 4.18 | |
| | 30 | 10.27 | 3.92 | |
| | 90 | 9.19 | 2.84 | |
| | 120 | 8.74 | 2.39 | |
| 30 8:45 | 1125 | 6.27 | —— | |

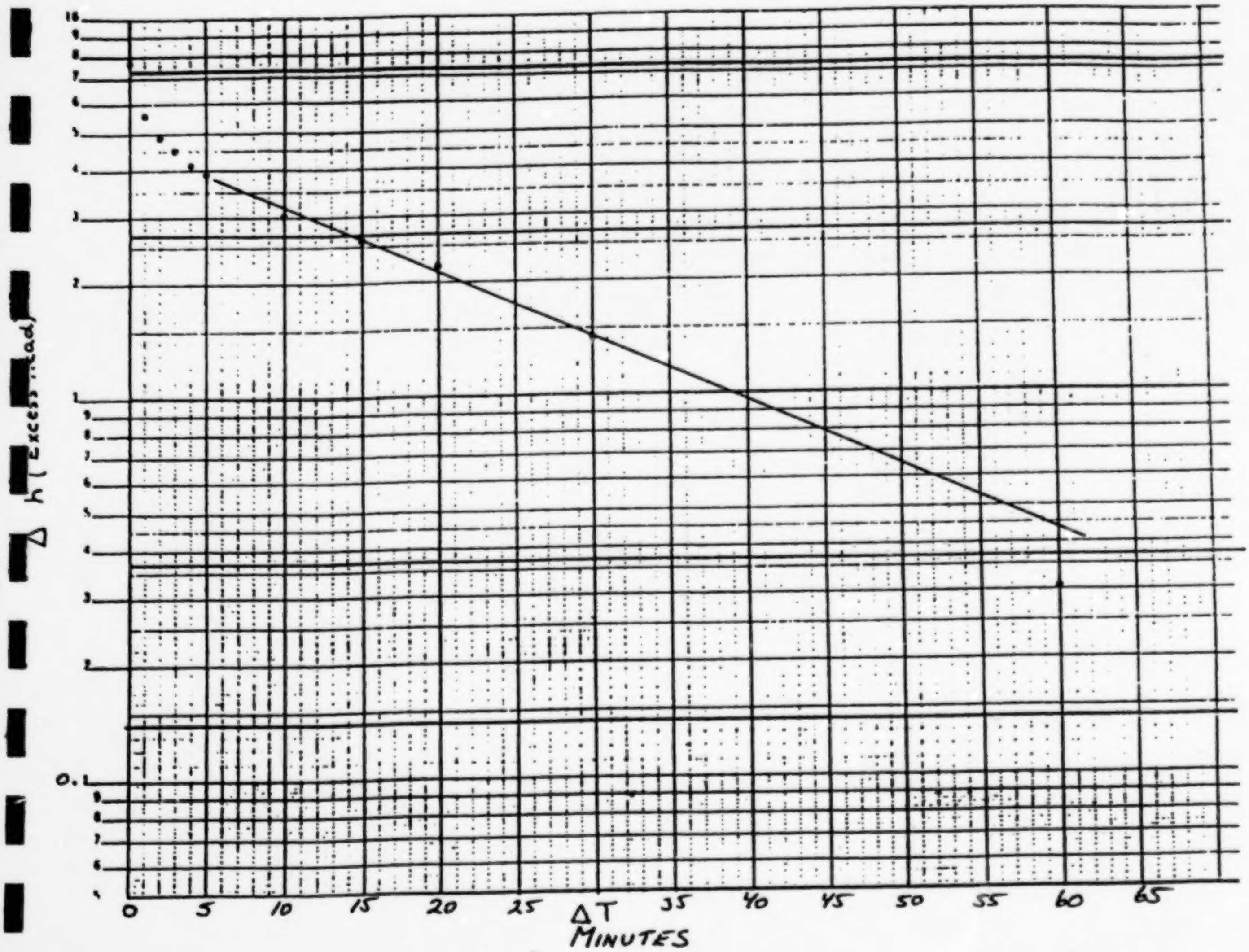
PA-6

Permeability Test Sheet for Test No D P-2 (Bail Test)

Sheet 1 of 2

Test Interval 5.79 to 7.32 (metres)

19 to 24 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln} \left( \frac{2\sqrt{M}}{D} xL \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 900} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$K = 7.5 \times 10^{-5}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 900 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (D-P2)

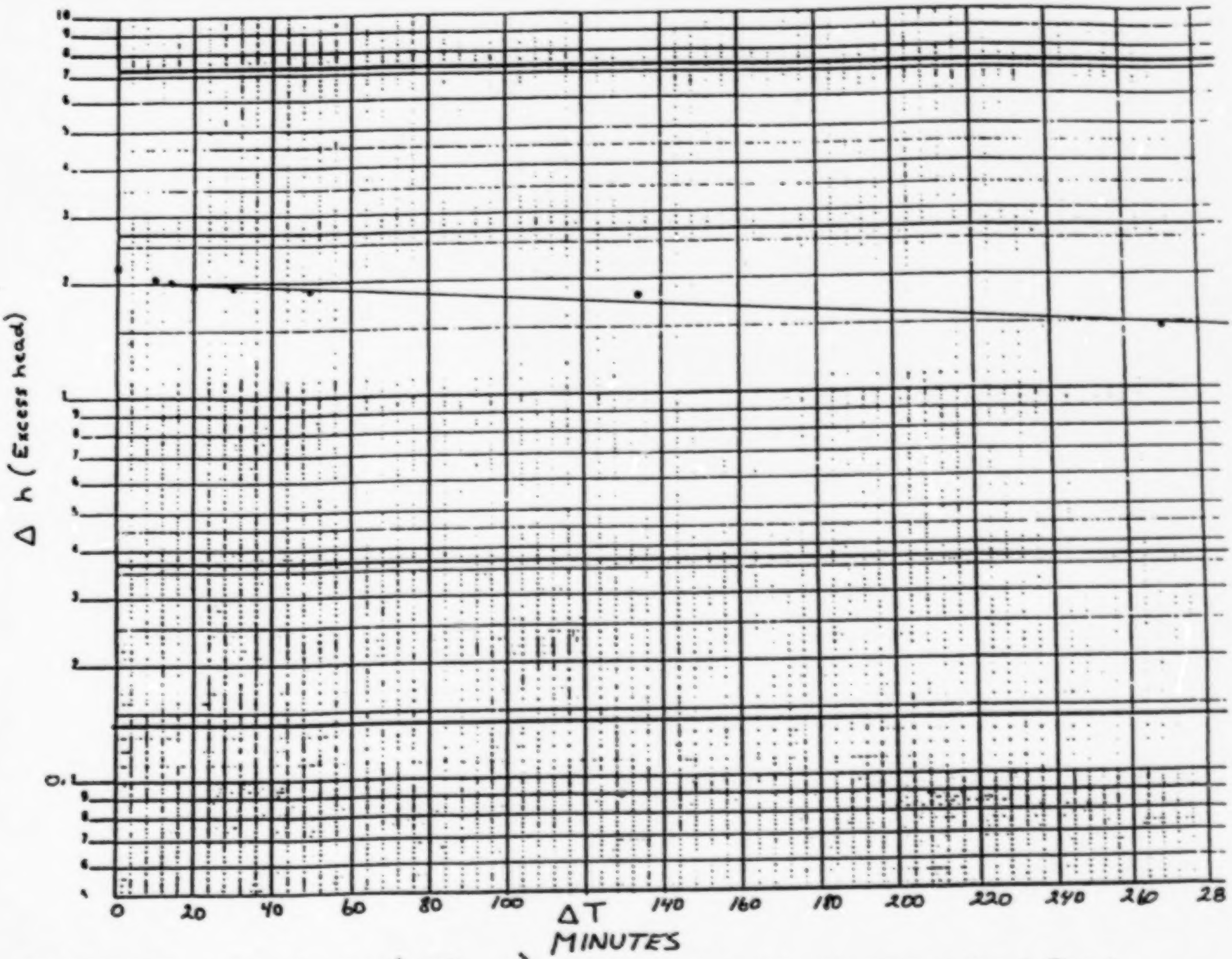
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 14:40 | | 6.20m | | |
| 24 13:55 | | 6.19 | | |
| 14:15 | | —— | | Attempted to develop with $N_2$ purge |
| 25 10:48 | | 6.19 | | ⇒ developed by bailing |
| 29 13:45 | | 6.17 | | Datum (for hydraulic cond. test) |
| 14:25 | 0 min | 6.95 | 0.78 m | Rising Head (Bail) Test. |
| | 1 | 6.73 | 0.56 | |
| | 2 | 6.66 | 0.49 | |
| | 3 | 6.62 | 0.45 | |
| | 4 | 6.58 | 0.41 | |
| | 5 | 6.56 | 0.39 | |
| | 10 | 6.47 | 0.30 | |
| | 15 | 6.43 | 0.26 | |
| | 20 | 6.39 | 0.22 | |
| | 30 | 6.31 | 0.14 | |
| | 60 | 6.20 | 0.03 | |
| | 95 | 6.19 | 0.02 | |
| 30 8:45 | 1100 | 6.18 | 0.01 | |

PA-6

**Permeability Test Sheet for Test No** F P-1 (Bail Test) **Sheet** 1 **of** 2

**Test Interval** 5.18 **to** 6.71 **(metres)**

17 **to** 22 **(feet)**



**CALCULATIONS:** $K = \frac{d^2}{8LT_i} \text{Ln}\left(\frac{2\sqrt{M}}{D} \times L\right)$

**where:** D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 32,416 seconds

$$K = \frac{5.25^2}{8 \times 152 \times 32{,}416} \text{Ln}\left(\frac{2\sqrt{1}}{20.3} \times 152\right)$$

$$K = 1.9 \times 10^{-6} \text{ cm/sec}$$

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (F-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 12:16 | | 4.03m | | |
| 24 9:19 | | 4.01 | | |
| 26 18:00 | | 4.02 | | |
| 26 18:15 | | 6.13 | | Developed piezometer. |
| 28 12:25 | | 4.03 | | Datum (for hydraulic cond. test) |
| 12:35 | 0 min | 6.15 | 2.12m | Rising Head (Bail) Test |
| | 1 | 6.13 | 2.10 | |
| | 2 | 6.11 | 2.08 | |
| | 3 | 6.10 | 2.07 | |
| | 4 | 6.09 | 2.06 | |
| | 5 | 6.08 | 2.05 | |
| | 10 | 6.06 | 2.03 | |
| | 15 | 6.04 | 2.01 | |
| | 20 | 6.02 | 1.99 | |
| | 30 | 6.00 | 1.97 | |
| | 50 | 5.95 | 1.92 | |
| | 135 | 5.83 | 1.80 | |
| | 270 | 5.51 | 1.48 | |
| 29 8:35 | 1200 | 4.26 | 0.23 | |
| 16:30 | 1685 | 4.11 | 0.08 | |
| 30 8:20 | 2625 | 4.06 | 0.03 | |

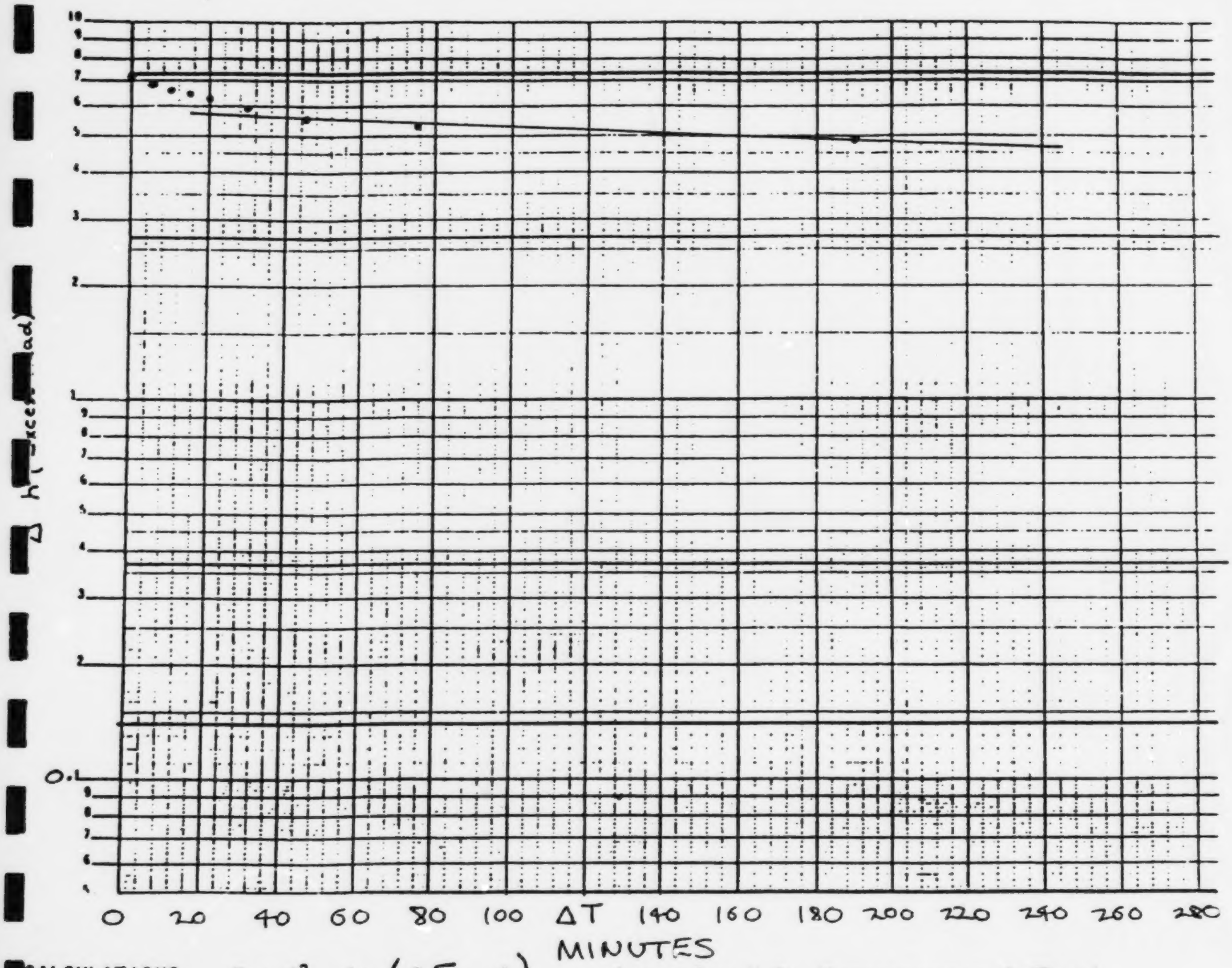
PA-6

Permeability Test Sheet for Test No G P-1 (Slug Test)

Sheet 1 of 2

Test Interval 6.10 to 7.62 (metres)

20 to 25 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln}\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{5.25^2}{8 \times 152 \times 63{,}969} \text{Ln}\left(\frac{2\sqrt{1}}{20.3} \times 152\right)$$

$$K = 9.6 \times 10^{-7} \text{ cm/sec}$$

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 63,969 seconds

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

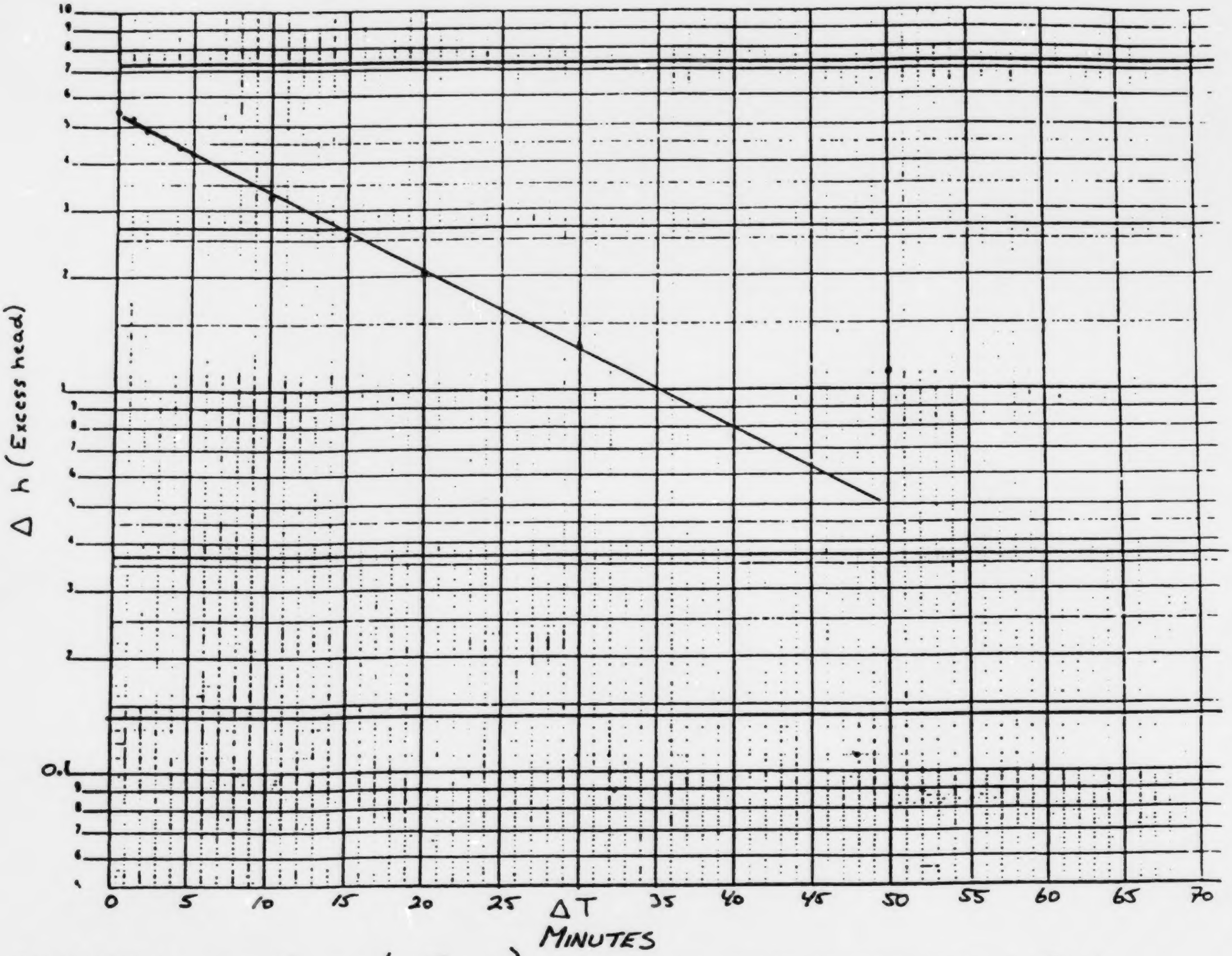
Pine Coulee (G-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:31 | | Dry | | |
| 24 16:30 | | Dry | | Datum = 8.05m |
| 28 13:45 | 0 min | 0.93m | 7.12m | Falling Head (Slug Test) |
| | 1 | 1.10 | 6.95 | |
| | 2 | 1.12 | 6.93 | |
| | 3 | 1.14 | 6.91 | |
| | 4 | 1.18 | 6.87 | |
| | 5 | 1.23 | 6.82 | |
| | 10 | 1.44 | 6.61 | |
| | 15 | 1.62 | 6.43 | |
| | 20 | 1.80 | 6.25 | |
| | 30 | 2.14 | 5.91 | |
| | 45 | 2.47 | 5.58 | |
| | 75 | 2.70 | 5.35 | |
| | 190 | 3.13 | 4.92 | |
| 29 8:45 | 1140 | 3.72 | 4.33 | |
| 16:45 | 1620 | 3.95 | 4.10 | |
| 30 9:20 | 2435 | 4.37 | 3.68 | |

Permeability Test Sheet for Test No G P-2 (Bail Test) Sheet 1 of 2

Test Interval 26.97 to 30.02 (metres)

88.5 to 98.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln} \left( \frac{2\sqrt{M}}{D} xL \right)$

where: D = Hole diameter 15.2cm ( 6 in)

d = Tube diameter 5.25m (2.067in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 1230 seconds

$$K = \frac{5.25^2}{8 \times 305 \times 1230} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 305 \right)$$

$K = 3.4 \times 10^{-5}$ cm/sec

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (G-P2)

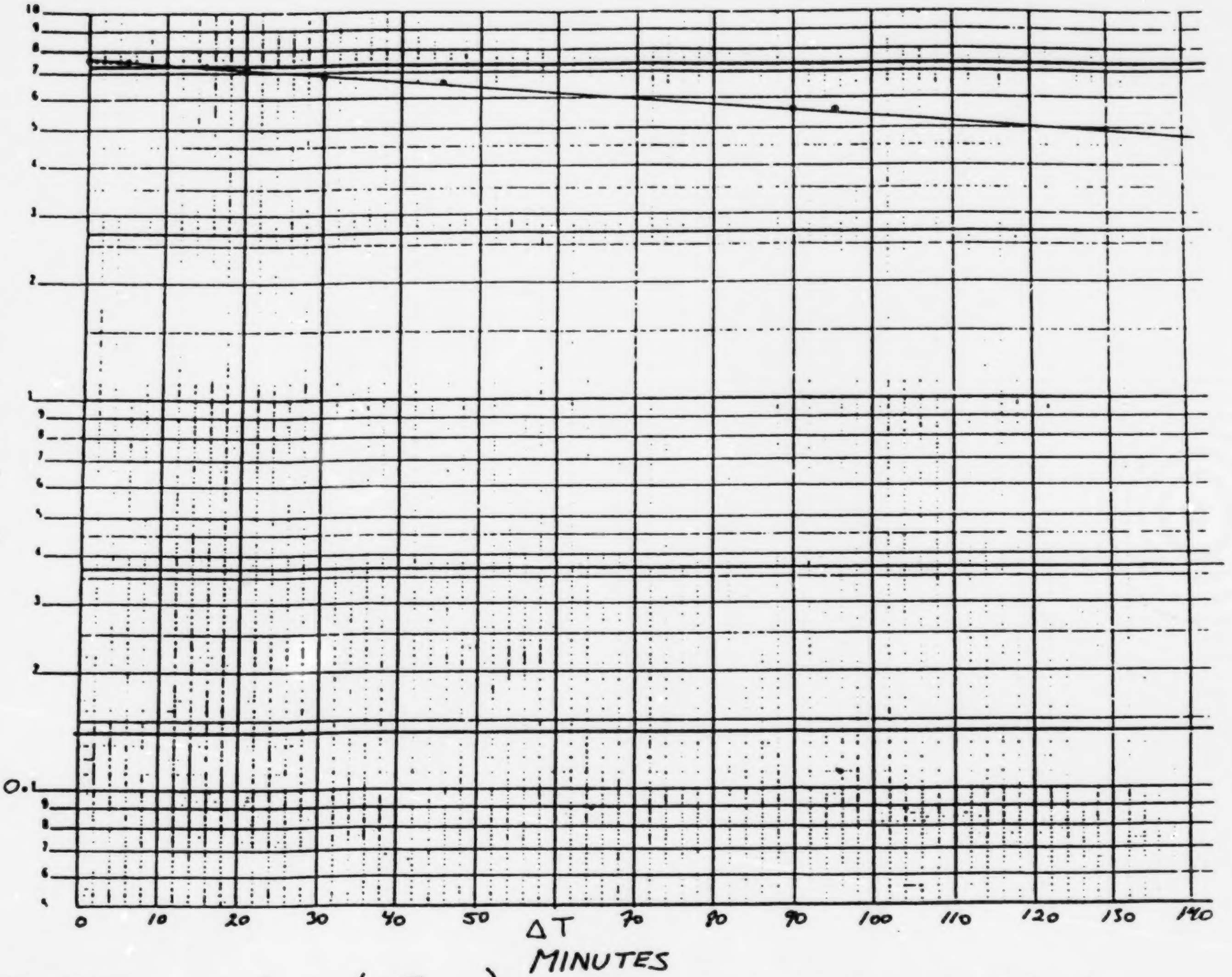
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:35 | | 12.60m | | |
| 24 16:30 | | 12.34 | | |
| 16:50 | | 19.85 | | Developed piezometer ⇒ clean water |
| 25 16:45 | | 12.47 | | |
| 26 18:00 | | 12.66 | | |
| 28 13:35 | | 12.66 | | Datum (For hydraulic cond. test) |
| 14:10 | 0 min | 18.14 | 5.48m | Rising Head (Bail) Test |
| | 1 | 17.82 | 5.16 | |
| | 2 | 17.54 | 4.88 | |
| | 3 | 17.29 | 4.63 | |
| | 4 | 17.07 | 4.41 | |
| | 5 | 16.84 | 4.18 | |
| | 10 | 15.89 | 3.23 | |
| | 15 | 15.16 | 2.50 | |
| | 20 | 14.68 | 2.02 | |
| | 30 | 14.00 | 1.34 | |
| | 50 | 13.78 | 1.12 | |
| | 165 | 12.95 | 0.29 | |
| 29 8:40 | 1110 | 12.67 | 0.01 | |
| 16:45 | 1595 | 12.66 | 0.00 | |
| 30 9:25 | 2595 | 12.66 | 0.00 | |

PA-6

Permeability Test Sheet for Test No H P-1 (Bail Test) Sheet 1 of 2

Test Interval 10.36 to 13.41 (metres)

34 to 44 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ Ln \left( \frac{2\sqrt{M}}{D} \ xL \right)$

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 20,357 seconds

$$K = \frac{5.25^2}{8 \times 305 \times 20{,}357} Ln \left( \frac{2\sqrt{1}}{20.3} \times 305 \right)$$

$$K = 1.9 \times 10^{-6} \text{ cm/sec}$$

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (H-P1)

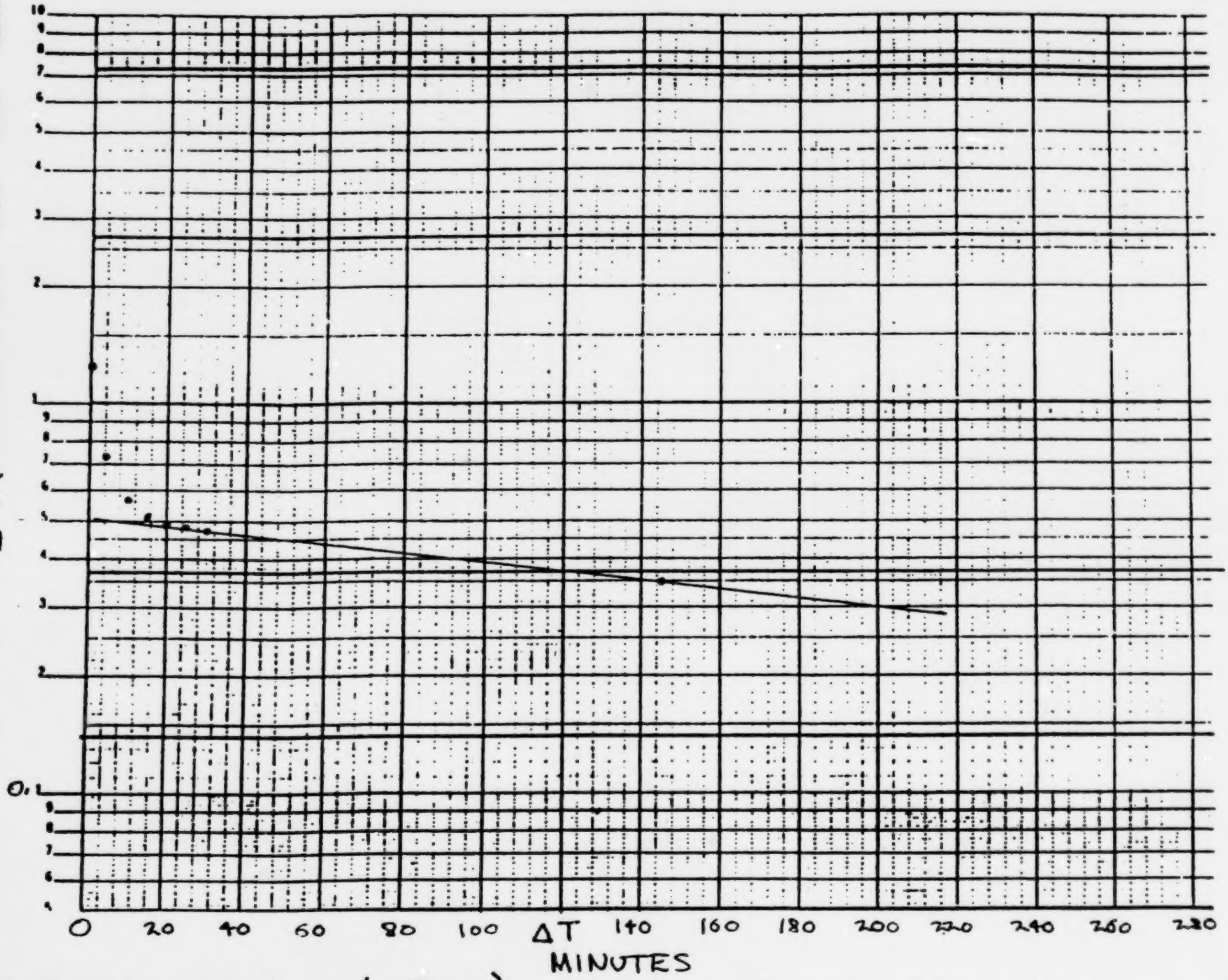
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:46 | | 4.13m | | |
| 17:20 | | 10.12 | | Developed piezometer ⇒ clean water |
| 25 14:05 | | 4.14 | | Datum (for hydraulic cond. test) |
| 14:46 | | 9.85 | | Developed piezometer with $N_2$ purge |
| 26 9:32 | | 4.51 | | |
| 17:00 | | 4.30 | | |
| 27 17:50 | | 4.15 | | |
| 18:15 | | 11.65 | | Developed piezometer by bailing |
| 28 11:15 | | 4.70 | | |
| 11:35 | 0 min | 11.75 | 7.61m | Rising Head (Bail) Test |
| | 1 | 11.72 | 7.58 | |
| | 2 | 11.71 | 7.57 | |
| | 3 | 11.70 | 7.56 | |
| | 4 | 11.69 | 7.55 | |
| | 5 | 11.67 | 7.53 | |
| | 10 | 11.55 | 7.41 | |
| | 15 | 11.37 | 7.23 | |
| | 20 | 11.26 | 7.12 | |
| | 30 | 11.05 | 6.91 | |
| | 45 | 10.85 | 6.71 | |
| | 95 | 9.76 | 5.62 | |
| | 190 | 8.32 | 4.18 | |
| | 325 | 7.06 | 2.92 | |
| 29 8:40 | 1265 | 4.57 | 0.43 | |
| 16:35 | 1740 | 4.31 | 0.17 | |
| 30 9:15 | 2740 | 4.14 | 0.00 | |

PA-6

**Permeability Test Sheet for Test No** H P-2 (Slug Test) **Sheet** 1 **of** 2

**Test Interval** 2.44 **to** 3.96 **(metres)**

8 **to** 13 **(feet)**



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln}\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{5.25^2}{8 \times 152 \times 21{,}982} \text{Ln}\left(\frac{2\sqrt{1}}{15.2} \times 152\right)$$

$K = 3.1 \times 10^{-6}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 21,982 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pike Coulee (H-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:50 | | Dry | | |
| 25 14:11 | | Dry | | Datum = 4.24 m |
| 14:15 | 0 min | 2.98 m | 1.26 m | Falling Head (Slug) Test |
| | 1 | 3.23 | 1.01 | |
| | 2 | 3.35 | 0.89 | |
| | 3 | 3.44 | 0.80 | |
| | 4 | 3.50 | 0.74 | |
| | 5 | 3.55 | 0.69 | |
| | 10 | 3.67 | 0.57 | |
| | 15 | 3.73 | 0.51 | |
| | 20 | 3.75 | 0.49 | |
| | 25 | 3.76 | 0.48 | |
| | 30 | 3.77 | 0.47 | |
| | 145 | 3.89 | 0.35 | |
| 26 9:35 | 1160 | 4.20 | 0.04 | |
| 17:00 | 1605 | 4.20 | 0.04 | |

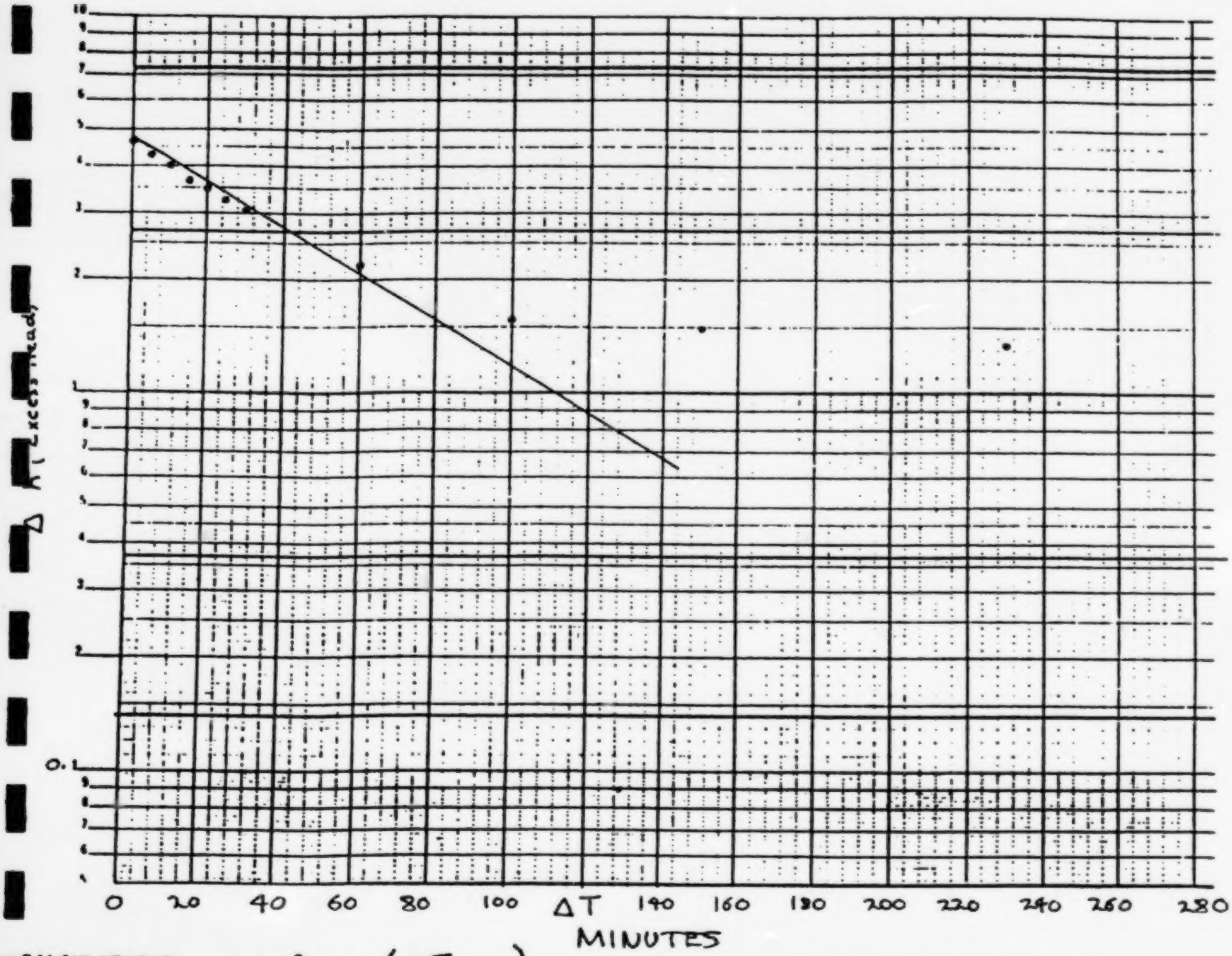
PA-6

Permeability Test Sheet for Test No I P-1 (Slug Test)

Sheet 1 of 2

Test Interval 7.01 to 8.53 (metres)

23 to 28 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln} \left( \frac{2\sqrt{M}}{D} xL \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 4200} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$K = 1.6 \times 10^{-5}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 4200 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (I-P1)

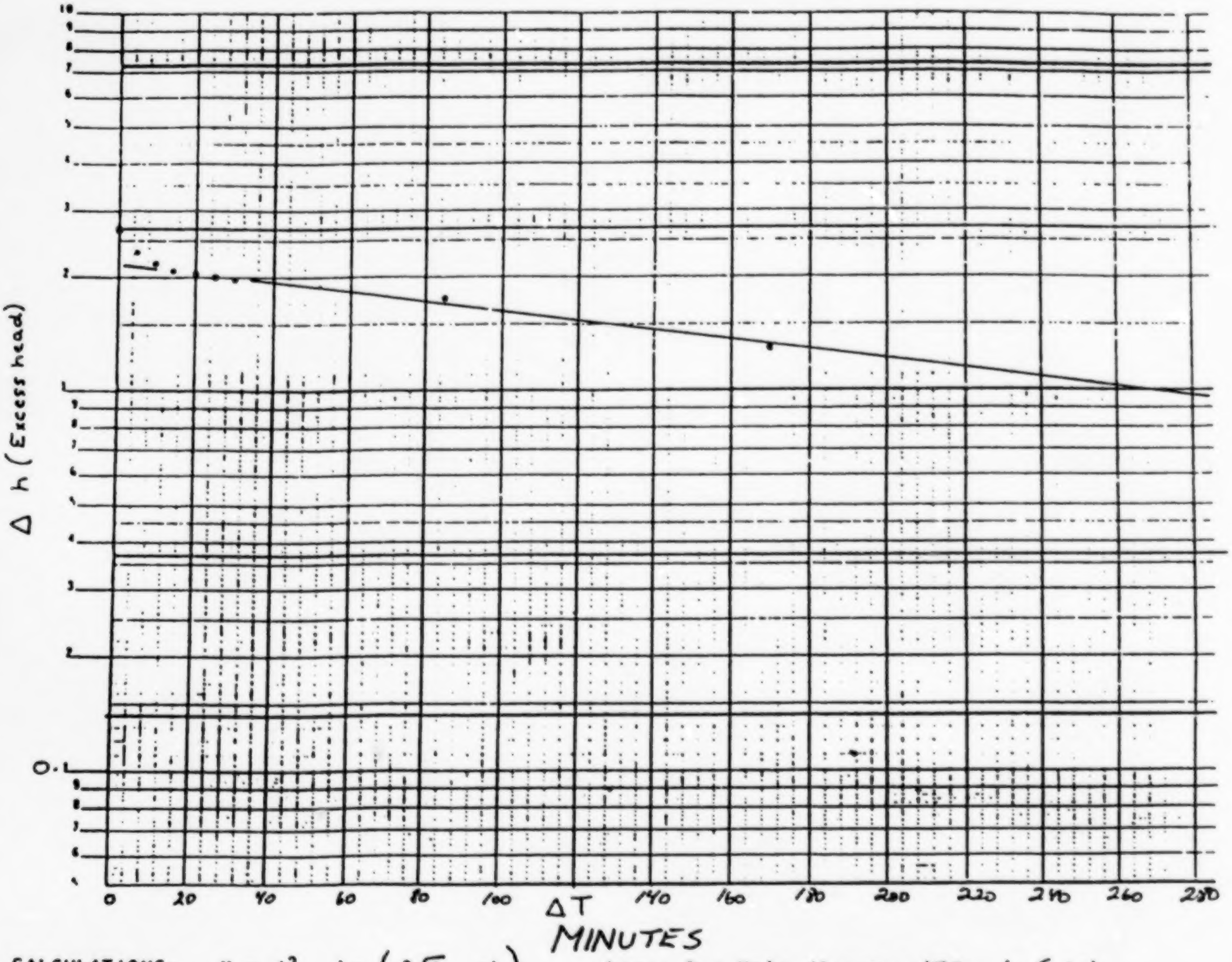
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:57 | | Dry | | |
| 25 11:54 | | Dry | | Datum = 8.90m |
| 12:20 | 0min | 4.22m | 4.68m | Falling Head (Slug) Test |
| | 1 | 4.29 | 4.61 | |
| | 2 | 4.35 | 4.55 | |
| | 3 | 4.42 | 4.48 | |
| | 4 | 4.50 | 4.40 | |
| | 5 | 4.58 | 4.32 | |
| | 10 | 4.91 | 3.99 | |
| | 15 | 5.21 | 3.69 | |
| | 20 | 5.43 | 3.47 | |
| | 25 | 5.66 | 3.24 | |
| | 30 | 5.86 | 3.04 | |
| | 60 | 6.73 | 2.17 | |
| | 100 | 7.33 | 1.57 | |
| | 150 | 7.41 | 1.49 | |
| | 230 | 7.56 | 1.34 | |
| 26 9:25 | 1265 | 8.26 | 0.64 | |
| 16:57 | 1717 | 8.35 | 0.55 | |
| 27 12:40 | 2900 | 8.61 | 0.29 | |

PA-6

**Permeability Test Sheet for Test No** I P-2 (Slug Test) **Sheet** 1 of 2

Test Interval 2.90 to 4.42 (metres)

9.5 to 14.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ Ln \left( \frac{2\sqrt{M}}{D} xL \right)$

where: D = Hole diameter 15.2cm ( 6 in)

d = Tube diameter 5.25cm (2.067in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 20,520 seconds

$$K = \frac{5.25^2}{8 \times 152 \times 20{,}520} Ln \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$K = 3.3 \times 10^{-6}$ cm/sec

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (I-P2)

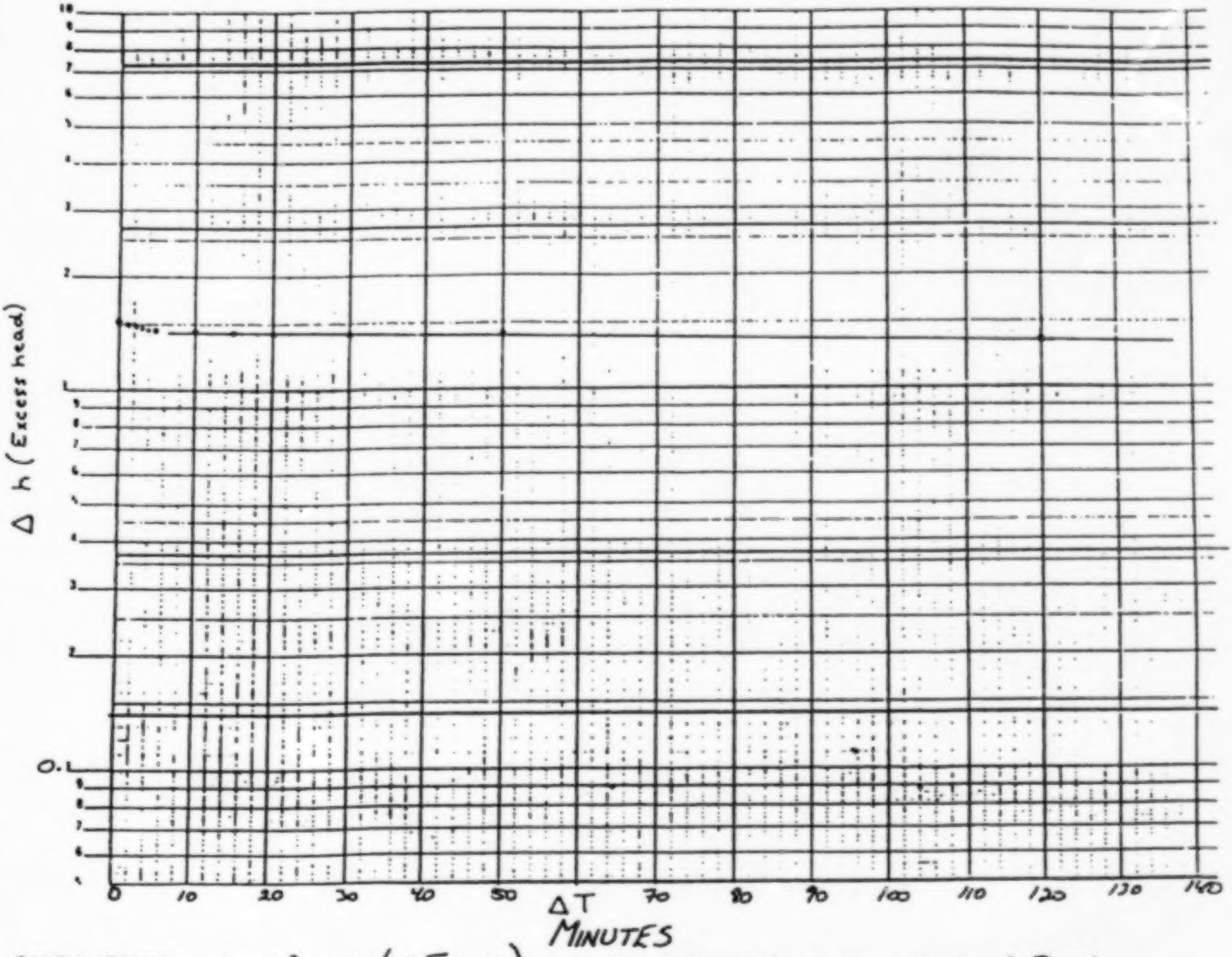
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 12:00 | | Dry | | |
| 25 11:54 | | Dry | | Datum = 4.92 m |
| 13:30 | 0 min | 2.25 m | 2.67 m | Falling Head (Slug) Test |
| | 1 | 2.34 | 2.58 | |
| | 2 | 2.39 | 2.53 | |
| | 3 | 2.45 | 2.47 | |
| | 4 | 2.51 | 2.41 | |
| | 5 | 2.56 | 2.36 | |
| | 10 | 2.74 | 2.18 | |
| | 15 | 2.83 | 2.09 | |
| | 20 | 2.87 | 2.05 | |
| | 25 | 2.92 | 2.00 | |
| | 30 | 2.95 | 1.97 | |
| | 85 | 3.22 | 1.70 | |
| | 170 | 3.57 | 1.35 | |
| 26 9:30 | 1200 | 4.92 | 0.00 | |
| 16:58 | 1648 | 4.92 | 0.00 | |

PA-6

Permeability Test Sheet for Test No JP-1
(Bail Test)

Sheet 1 of 2

Test Interval 5.49 to 7.01 (metres)
18 to 23 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{ Ln} \left( \frac{2\sqrt{M}}{D} \text{ x} L \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 93{,}369} \text{Ln} \left( \frac{2\sqrt{1}}{20.3} \times 152 \right)$$

$K = 6.6 \times 10^{-7}$ cm/sec

where: D = Hole diameter 20.3 cm ( 8 in)
d = Tube diameter 5.25 cm (2.067 in)
M = $K_H/K_V$ = ANISOTROPY = 1
K = Hydraulic Conductivity
L = Test Length 152 cm ( 60 in)
Ti = Time Interval for Excess Head ( h) to Decay by 63%
= Time for Excess to Drop from One Bold Line to the Next Bold Line
= 93,369 seconds

# GROUNDWATER SAMPLING FIELD RECORD

PITEAU & ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

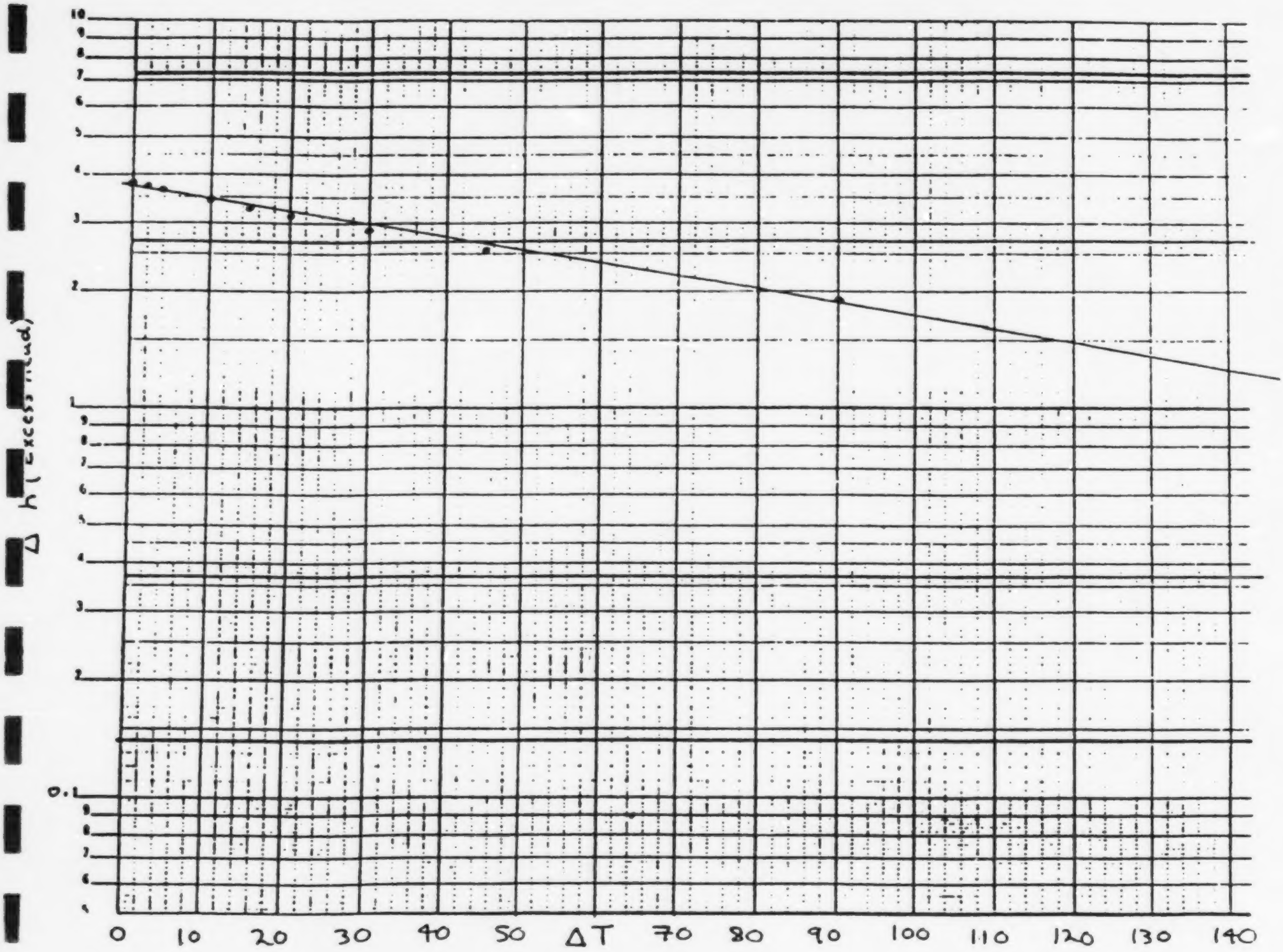
Pine Coulee (J-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:17 | | 4.66m | | |
| 24 16:10 | | 4.62 | | |
| 16:17 | | 5.57 | | Developed piezometer ⇒ clean water |
| 25 15:29 | | 4.75 | | Datum (for hydraulic cond. test) |
| 26 16:08 | | 4.69 | | |
| 16:31 | | 5.57 | | Developed piezometer with $N_2$ purge |
| 27 17:20 | | 4.68 | | |
| 17:32 | | 6.35 | | Developed piezometer by bailing. |
| 28 10:00 | | 5.24 | | |
| 10:10 | 0 min | 6.25 | 1.50m | Rising Head (Bail) Test. |
| | 1 | 6.21 | 1.46 | |
| | 2 | 6.20 | 1.45 | |
| | 3 | 6.20 | 1.45 | |
| | 4 | 6.20 | 1.45 | |
| | 5 | 6.19 | 1.44 | |
| | 10 | 6.18 | 1.43 | |
| | 15 | 6.18 | 1.43 | |
| | 20 | 6.17 | 1.42 | |
| | 30 | 6.16 | 1.41 | |
| | 50 | 6.15 | 1.40 | |
| | 120 | 6.10 | 1.35 | |
| | 185 | 6.05 | 1.30 | |
| | 295 | 5.98 | 1.23 | |
| | 400 | 5.91 | 1.16 | |
| 29 8:50 | 1360 | 5.10 | 0.35 | |
| 16:40 | 1830 | 4.91 | 0.16 | |
| 30 9:30 | 2840 | 4.75 | 0.00 | |

Permeability Test Sheet for Test No J P-2 (Slug Test) Sheet 1 of 2

Test Interval 274 to 4.27 (metres)

9 to 14 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln} \left( \frac{2\sqrt{M}}{D} xL \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 7{,}560} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$$K = 9.0 \times 10^{-6} \text{ cm/sec}$$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 7,560 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (J-P2)

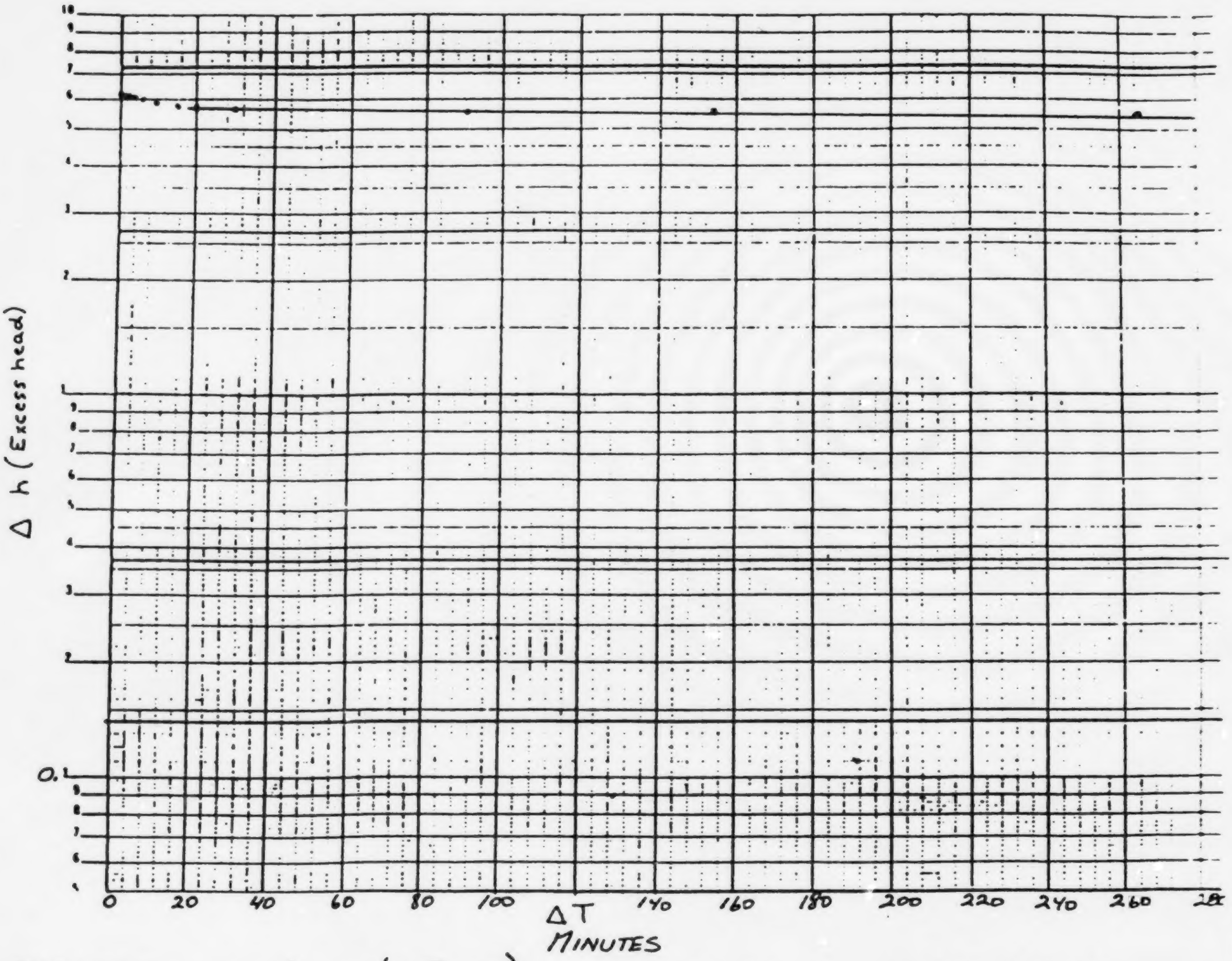
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug23 11:20 | | Dry | | |
| 26 16:11 | | Dry | | Datum = 4.48m |
| 16:20 | 0 min | 0.61m | 3.87m | Falling Head (Slug) Test |
| | 1 | 0.67 | 3.81 | |
| | 2 | 0.71 | 3.77 | |
| | 3 | 0.76 | 3.72 | |
| | 4 | 0.80 | 3.68 | |
| | 5 | 0.85 | 3.63 | |
| | 10 | 1.02 | 3.46 | |
| | 15 | 1.18 | 3.30 | |
| | 20 | 1.33 | 3.15 | |
| | 30 | 1.59 | 2.89 | |
| | 45 | 1.93 | 2.55 | |
| | 90 | 2.58 | 1.90 | |
| 27 8:25 | 965 | 4.01 | 0.47 | |
| 12:35 | 1215 | 4.10 | 0.38 | |
| 17:20 | 1500 | 4.16 | 0.32 | |
| 28 10:00 | 2500 | 4.32 | 0.16 | |

PA-6

Permeability Test Sheet for Test No J P-3 (Bail Test) Sheet 1 of 2

Test Interval 18.29 to 21.34 (metres)

60 to 70 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ln\left(\frac{2\sqrt{H}}{D} xL\right)$

$$K = \frac{5.25^2}{8 \times 305 \times 301{,}629} \ln\left(\frac{2\sqrt{1}}{15.2} \times 305\right)$$

$K = 1.4 \times 10^{-7}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$H = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold

= 301,629 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (J-P3)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:21 | | 13.77 m | | |
| 24 16:15 | | 11.66 | | |
| 16:20 | | 15.89 | | Developed piezometer ⇒ clean water |
| 25 15:30 | | 14.05 | | |
| 26 16:10 | | 12.33 | | |
| 27 17:20 | | 10.82 | | |
| 17:45 | | 15.77 | | Developed piezometer by bailing. |
| 28 10:00 | | 14.38 | | Datum (for hydralic cond. test) |
| 10:40 | 0 min | 20.44 | 6.06m | Rising Head (Bail) Test. |
| | 1 | 20.41 | 6.03 | |
| | 2 | 20.37 | 5.99 | |
| | 3 | 20.35 | 5.97 | |
| | 4 | 20.34 | 5.96 | |
| | 5 | 20.33 | 5.95 | |
| | 10 | 20.31 | 5.93 | |
| | 15 | 20.29 | 5.91 | |
| | 20 | 20.27 | 5.89 | |
| | 30 | 20.25 | 5.87 | |
| | 90 | 20.20 | 5.82 | |
| | 155 | 20.15 | 5.77 | |
| | 265 | 20.09 | 5.71 | |
| | 370 | 20.01 | 5.63 | |
| 29 8:50 | 1330 | 19.38 | 5.00 | |
| 16:40 | 1800 | 19.06 | 4.68 | |
| 30 9:30 | 2810 | 18.08 | 3.70 | |

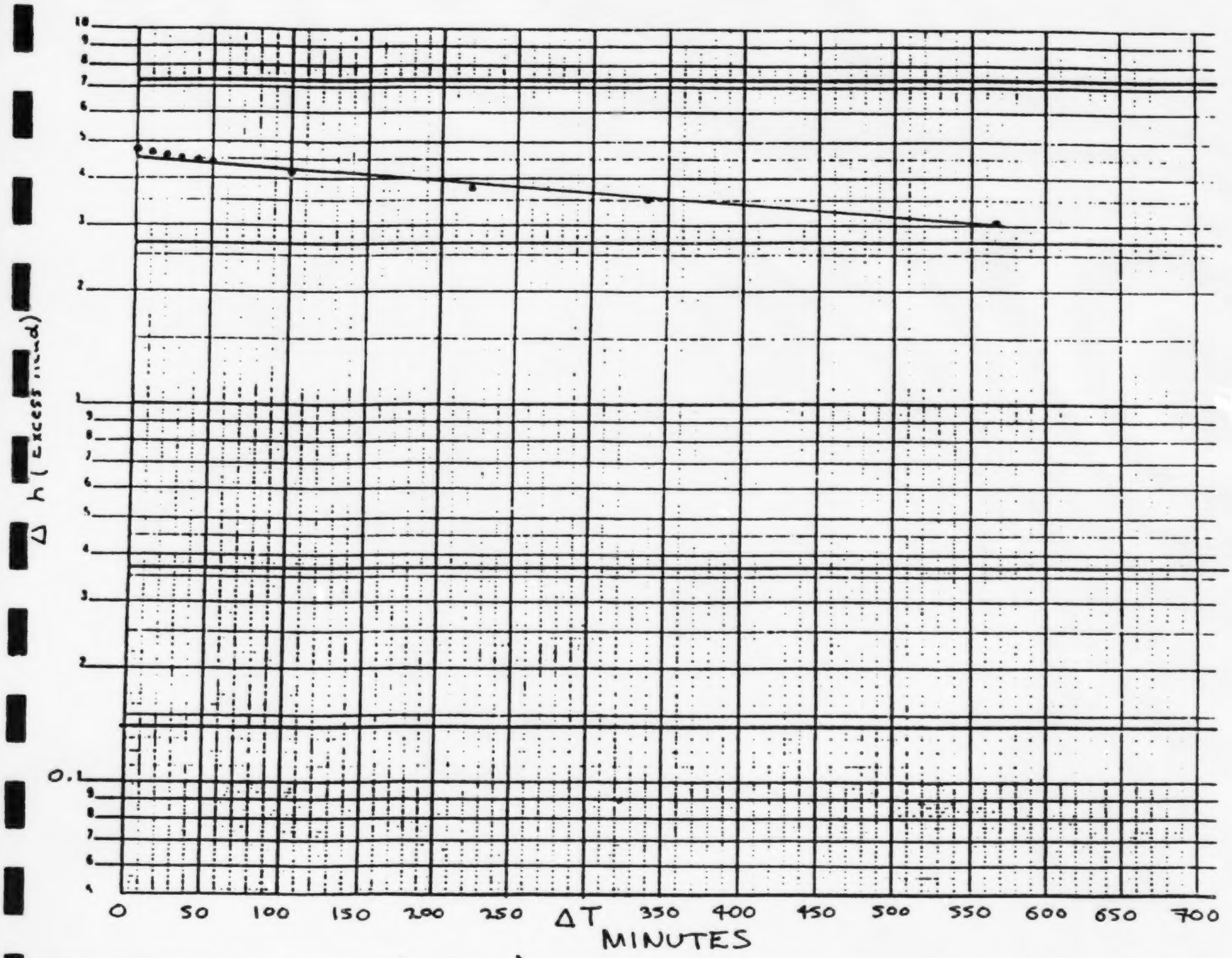
PA-6

Permeability Test Sheet for Test No K P-1 (Slug Test)

Sheet 1 of 2

Test Interval 3.05 to 4.57 (metres)

10 to 15 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \; Ln\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{5.25^2}{8 \times 152 \times 74{,}250} Ln\left(\frac{2\sqrt{1}}{20.3} \times 152\right)$$

$K = 8.3 \times 10^{-7}$ cm/sec

where: D = Hole diameter 20.3 cm ( 8 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 74,250 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (K-P1)

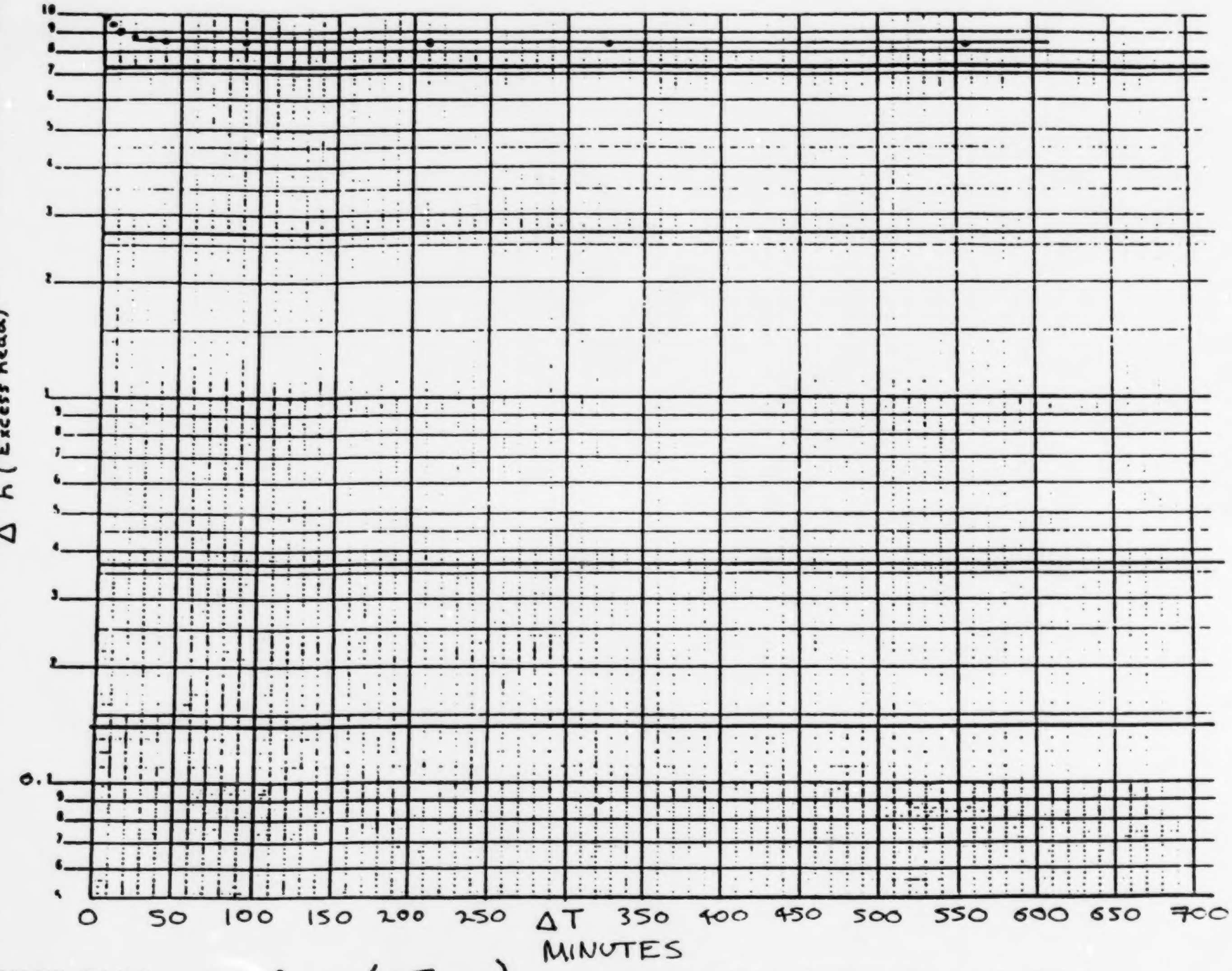
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 9:42 | | Dry | | |
| 25 15:50 | | Dry | | |
| 27 9:00 | | Dry | | Datum = 4.99m |
| 9:10 | 0 min | 0.20 m | 4.79m | Falling Head (Slug) Test |
| | 1 | 0.23 | 4.76 | |
| | 2 | 0.25 | 4.74 | |
| | 3 | 0.26 | 4.73 | |
| | 4 | 0.27 | 4.72 | |
| | 5 | 0.28 | 4.71 | |
| | 10 | 0.32 | 4.67 | |
| | 15 | 0.36 | 4.63 | |
| | 20 | 0.40 | 4.59 | |
| | 30 | 0.45 | 4.54 | |
| | 40 | 0.50 | 4.49 | |
| | 50 | 0.56 | 4.43 | |
| | 100 | 0.78 | 4.21 | |
| | 220 | 1.20 | 3.79 | |
| | 335 | 1.49 | 3.50 | |
| | 565 | 1.96 | 3.03 | |
| 28 9:15 | 1445 | 3.03 | 1.96 | |
| 16:15 | 1865 | 3.33 | 1.66 | |
| 29 9:00 | 2870 | 3.60 | 1.39 | |
| 30 9:45 | 4355 | 3.60 | 1.39 | |

PA-6

**Permeability Test Sheet for Test No** K P-2 (Slug Test) **Sheet** 1 **of** 2

**Test Interval** 13.11 **to** 14.63 **(metres)**

43 **to** 48 **(feet)**



**CALCULATIONS:** $K = \frac{d^2}{8LTi} \text{ Ln} \left( \frac{2\sqrt{M}}{D} xL \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 201{,}658} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$K = 3.4 \times 10^{-7}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 201,658 seconds

GROUNDWATER SAMPLING
FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (K-P2)

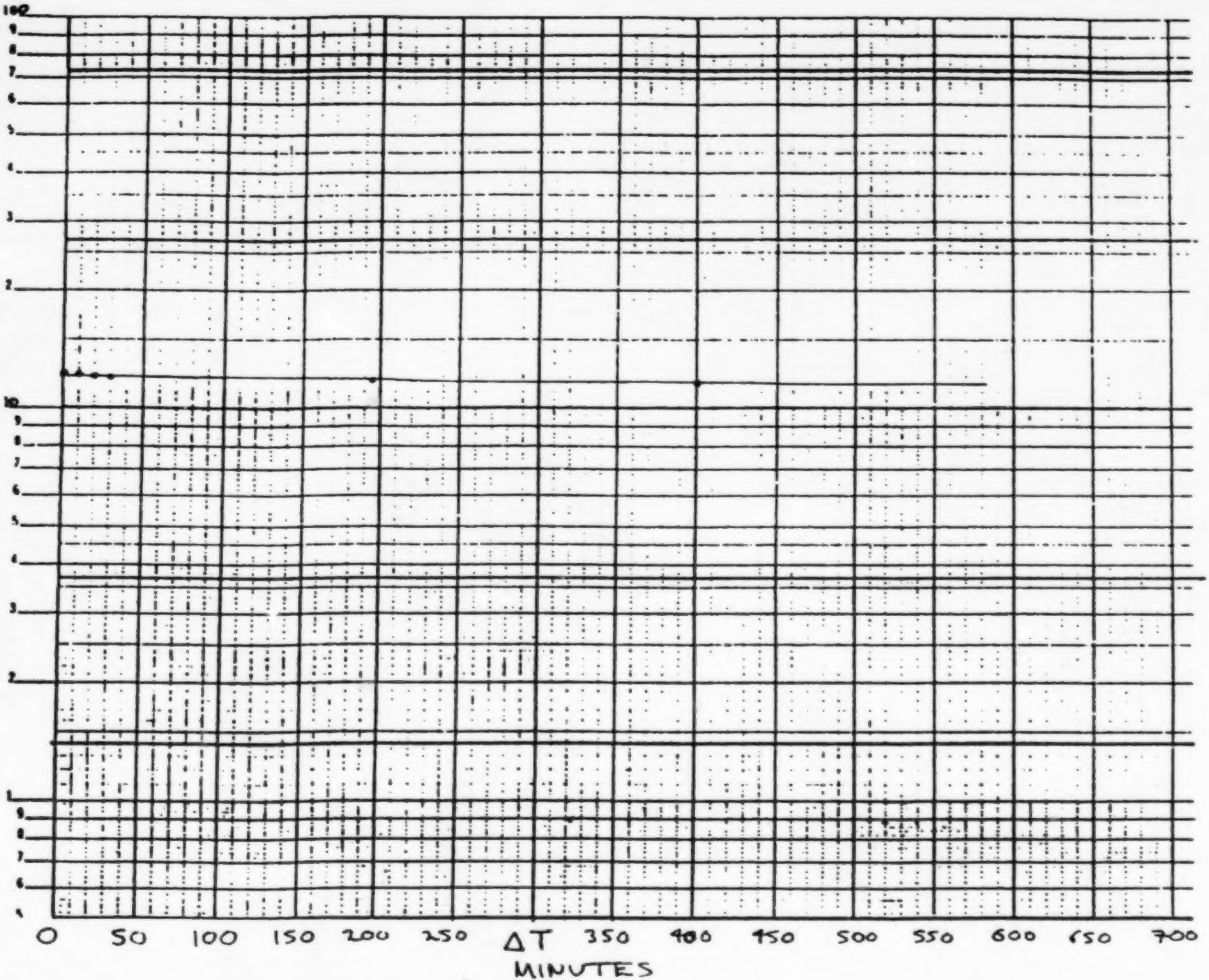
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 9:44 | | Dry | | |
| 25 15:50 | | Dry | | |
| 27 9:00 | | Dry | | Datum = 14.95m |
| 9:20 | 0 min | 5.03m | 9.92m | Falling Head (Slug) Test |
| | 1 | 5.13 | 9.82 | |
| | 2 | 5.22 | 9.73 | |
| | 3 | 5.32 | 9.63 | |
| | 4 | 5.43 | 9.52 | |
| | 5 | 5.52 | 9.43 | |
| | 10 | 5.92 | 9.03 | |
| | 15 | 6.13 | 8.82 | |
| | 20 | 6.20 | 8.75 | |
| | 30 | 6.26 | 8.69 | |
| | 40 | 6.30 | 8.65 | |
| | 90 | 6.40 | 8.55 | |
| | 210 | 6.47 | 8.48 | |
| | 325 | 6.50 | 8.45 | |
| | 555 | 6.54 | 8.41 | |
| 28 9:15 | 1435 | 6.63 | 8.32 | |
| 16:15 | 1855 | 6.66 | 8.29 | |
| 29 9:00 | 2860 | 6.71 | 8.24 | |
| 30 9:45 | 4345 | 6.78 | 8.17 | |

PA-6

Permeability Test Sheet for Test No L P-1 (Slug Test) Sheet 1 of 2

Test Interval 13.41 to 14.94 (metres)

44 to 49 (feet)



ALCULATIONS: $K = \frac{d^2}{8LT_i} \text{Ln}\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K=\frac{5.25^2}{8\times152\times1{,}030{,}239}\text{Ln}\left(\frac{2\sqrt{1}}{15.2}\times152\right)$$

$K = 6.6 \times 10^{-8}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.07 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 1,030,239 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (L-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 9:59 | | Dry | | |
| 25 16:05 | | Dry | | |
| 27 13:10 | | Dry | | Datum = 15.21m |
| 13:45 | 0 min | 3.05m | 12.16 m | Falling Head (Slug) Test |
| | 1 | 3.06 | 12.15 | |
| | 2 | 3.07 | 12.14 | |
| | 3 | 3.08 | 12.13 | |
| | 4 | 3.09 | 12.12 | |
| | 5 | 3.10 | 12.11 | |
| | 10 | 3.11 | 12.10 | |
| | 15 | 3.13 | 12.08 | |
| | 20 | 3.15 | 12.06 | |
| | 30 | 3.18 | 12.03 | |
| | 195 | 3.27 | 11.94 | |
| | 400 | 3.33 | 11.88 | |
| 28 9:25 | 1180 | 3.37 | 11.84 | |
| 16:35 | 1610 | 3.43 | 11.78 | |
| 29 9:25 | 2620 | 3.51 | 11.70 | |
| 30 10:15 | 4110 | 3.54 | 11.67 | |

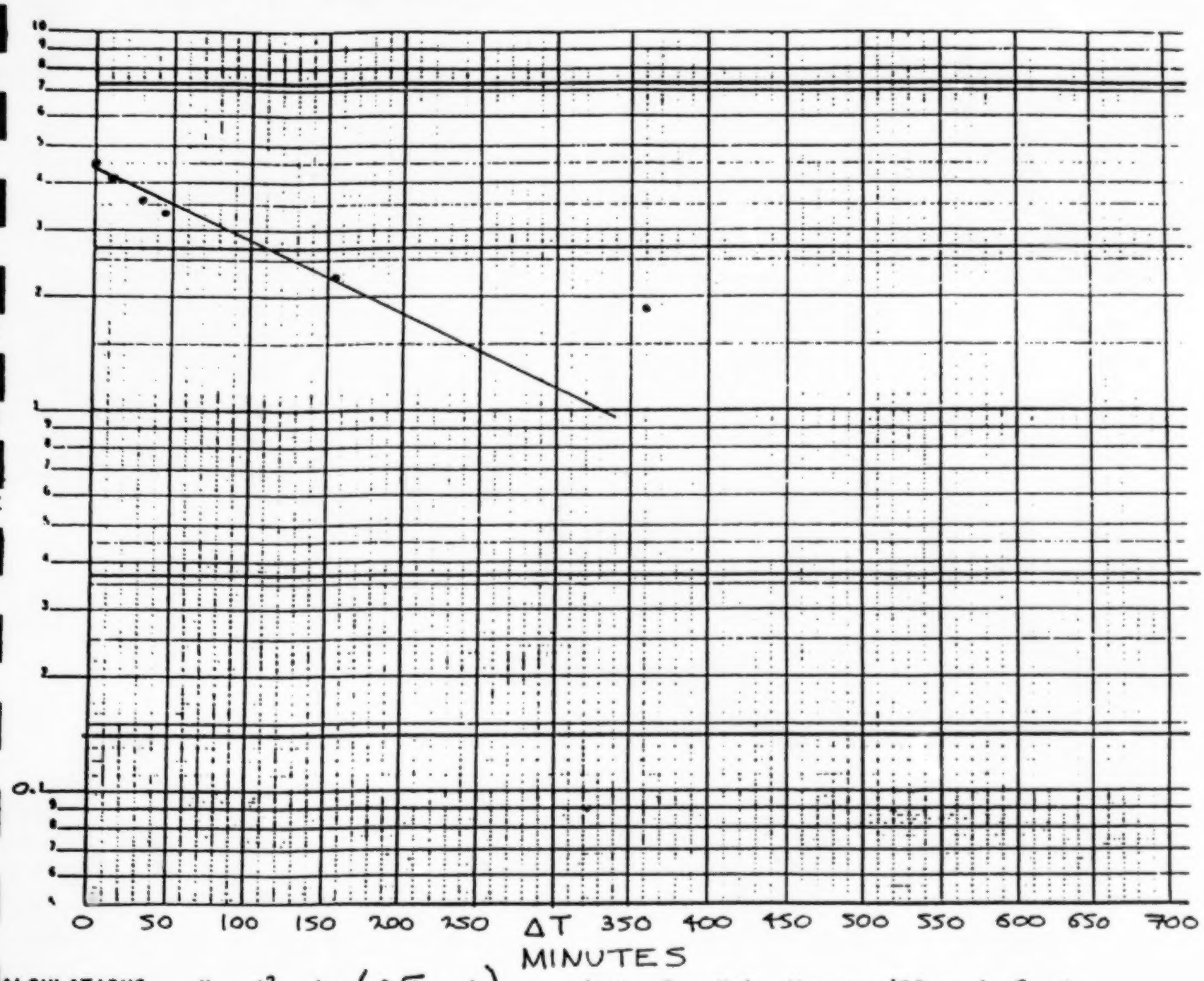
PA-6

Permeability Test Sheet for Test No L P-2 Sheet 1 of 2

(Slug Test)

Test Interval 3.05 to 4.57 (metres)

10 to 15 (feet)



ALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln}\left(\frac{2\sqrt{M}}{D} \times L\right)$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY

K = Hydraulic Conductivity

L = Test Length 152 cm ( 60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 13,020 seconds

$$K = \frac{5.25^2}{8 \times 152 \times 13{,}020} \text{Ln}\left(\frac{2\sqrt{1}}{15.2} \times 152\right)$$

$K = 5.2 \times 10^{-6}$ cm/sec

GROUNDWATER SAMPLING
FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (L-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 10:01 | | Dry | | |
| 25 16:01 | | Dry | | |
| 27 13:10 | | Dry | | Datum - 4.95m |
| 13:25 | 0min | 0.45m | 4.50 m | Falling Head (Slug) Test. |
| | 1 | 0.48 | 4.47 | |
| | 2 | 0.53 | 4.42 | |
| | 3 | 0.58 | 4.37 | |
| | 4 | 0.62 | 4.33 | |
| | 5 | 0.65 | 4.30 | |
| | 10 | 0.84 | 4.11 | |
| | 15 | 0.99 | 3.96 | |
| | 20 | 1.13 | 3.82 | |
| | 30 | 1.36 | 3.59 | |
| | 45 | 1.63 | 3.32 | |
| | 155 | 2.68 | 2.27 | |
| | 360 | 3.09 | 1.86 | |
| 28 9:25 | 1200 | 3.41 | 1.54 | |
| 11:35 | 1330 | 3.78 | 1.17 | |
| 29 9:25 | 2640 | 4.03 | 0.92 | |
| 30 10:15 | 4130 | 4.25 | 0.70 | |

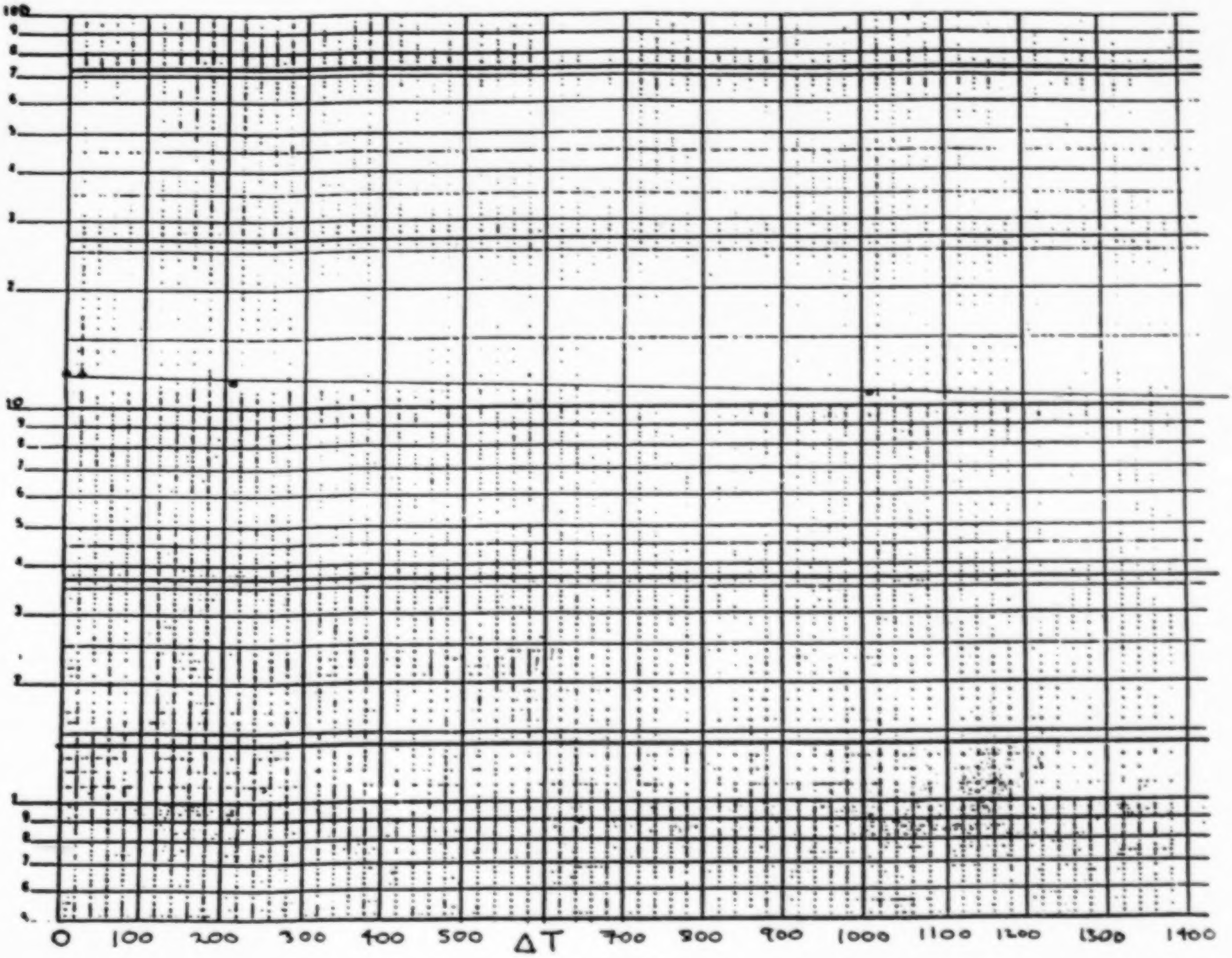
PA-6

Permeability Test Sheet for Test No M P-1 (Slug Test)

Sheet 1 of 2

Test Interval 12.04 to 12.65 (metres)

39.5 to 41.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \ln\left(\frac{2\sqrt{M}}{D} x L\right)$

$K = \frac{5.25^2}{8 \times 61 \times 1{,}028{,}396} \ln\left(\frac{2\sqrt{1}}{15.2} \times 61\right)$

$K = 1.1 \times 10^{-7}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 61 cm (24 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 1,028,396 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (M-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 10:20 | | 12.29m | | |
| 24 15:10 | | 12.28 | | |
| 15:15 | | — | | Attempted to develop with $N_2$ purge |
| 26 13:23 | | 12.07 | | |
| 27 8:45 | | 12.01 | | |
| 9:50 | | 12.92 | | Developed by bailing |
| 14:55 | | 12.99 | | Developed by bailing |
| 15:00 | | 12.98 | | Datum = 13.06 m |
| 15:15 | 0 min | 0.74 | 12.32m | Falling Head (Slug) Test |
| | 1 | 0.74 | 12.32 | |
| | 2 | 0.74 | 12.32 | |
| | 3 | 0.74 | 12.32 | |
| | 4 | 0.74 | 12.32 | |
| | 5 | 0.74 | 12.32 | |
| | 10 | 0.75 | 12.31 | |
| | 15 | 0.77 | 12.29 | |
| | 20 | 0.78 | 12.28 | |
| | 30 | 0.80 | 12.26 | |
| | 210 | 1.30 | 11.76 | |
| 28 9:30 | 1095 | 2.09 | 10.97 | |
| 16:25 | 1510 | 2.32 | 10.74 | |
| 29 9:10 | 2515 | 2.78 | 10.28 | |
| 30 10:05 | 4010 | 3.31 | 9.75 | |

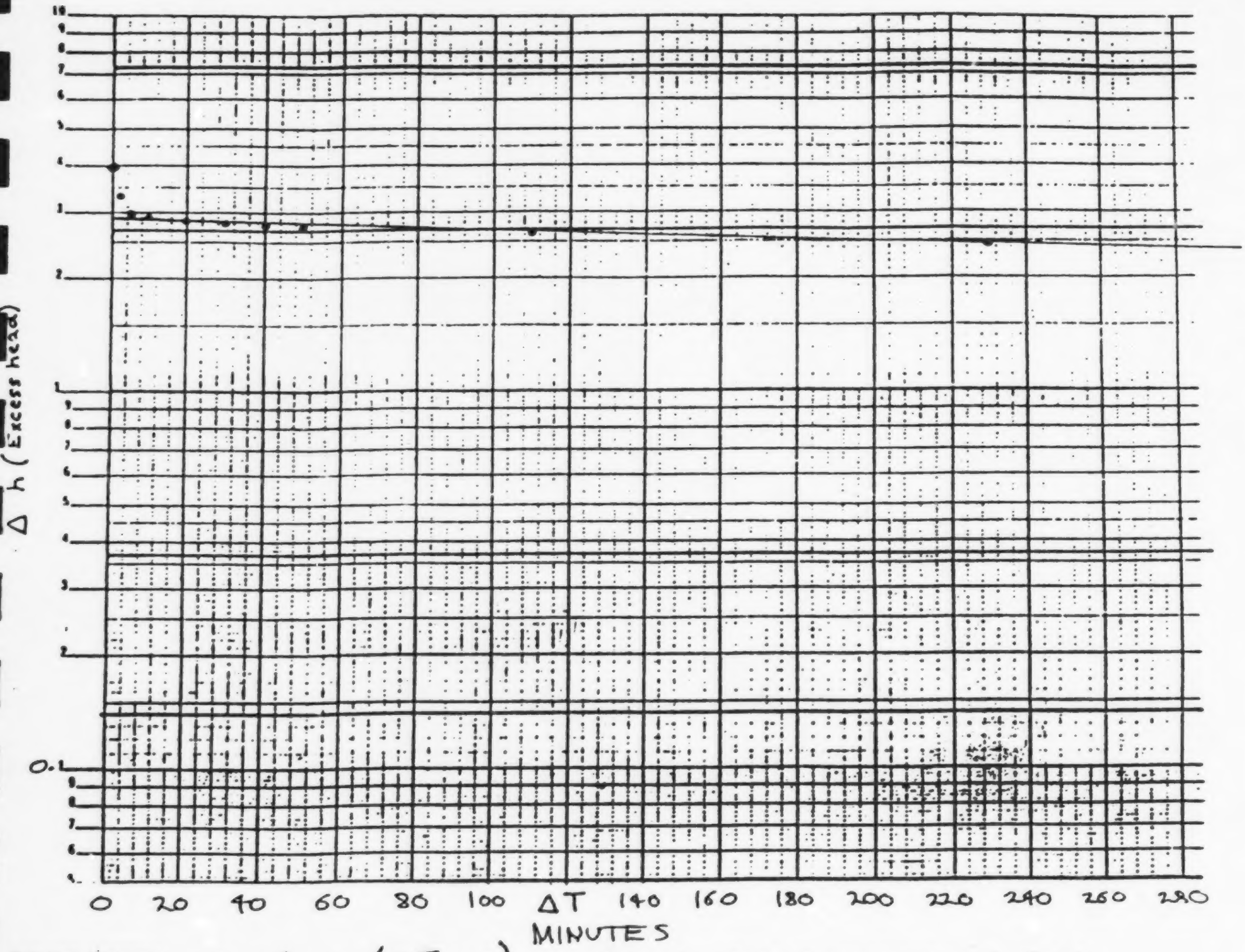
PA-6

Permeability Test Sheet for Test No M P-2 (Slug Test)

Sheet 1 of 2

Test Interval 3.05 to 4.57 (metres)

10 to 15 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \; Ln \left( \frac{2\sqrt{M}}{D} \; xL \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 84{,}672} Ln \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$K = 8.0 \times 10^{-7}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 84,672 seconds

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (M-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 10:25 | | Dry | | |
| 24 15:11 | | Dry | | Datum = 4.94m |
| 26 13:40 | 0 min | 0.95m | 3.99m | Falling Head (Slug) Test |
| | 1 | 1.37 | 3.57 | |
| | 2 | 1.65 | 3.29 | |
| | 3 | 1.83 | 3.11 | |
| | 4 | 1.92 | 3.02 | |
| | 5 | 1.98 | 2.96 | |
| | 10 | 2.03 | 2.91 | |
| | 15 | 2.06 | 2.88 | |
| | 20 | 2.08 | 2.86 | |
| | 30 | 2.13 | 2.81 | |
| | 40 | 2.17 | 2.77 | |
| | 50 | 2.20 | 2.74 | |
| | 110 | 2.33 | 2.61 | |
| | 230 | 2.49 | 2.45 | |
| 27 8:45 | 1145 | 3.09 | 1.85 | |
| 14:55 | 1515 | 3.22 | 1.72 | |
| 15:35 | 1555 | 3.24 | 1.70 | |
| 18:45 | 1745 | 3.30 | 1.64 | |
| 28 9:30 | 2630 | 3.54 | 1.40 | |
| 16:25 | 3045 | 3.62 | 1.32 | |
| 29 9:10 | 4050 | 3.69 | 1.25 | |
| 30 10:05 | 5545 | 3.69 | 1.25 | |

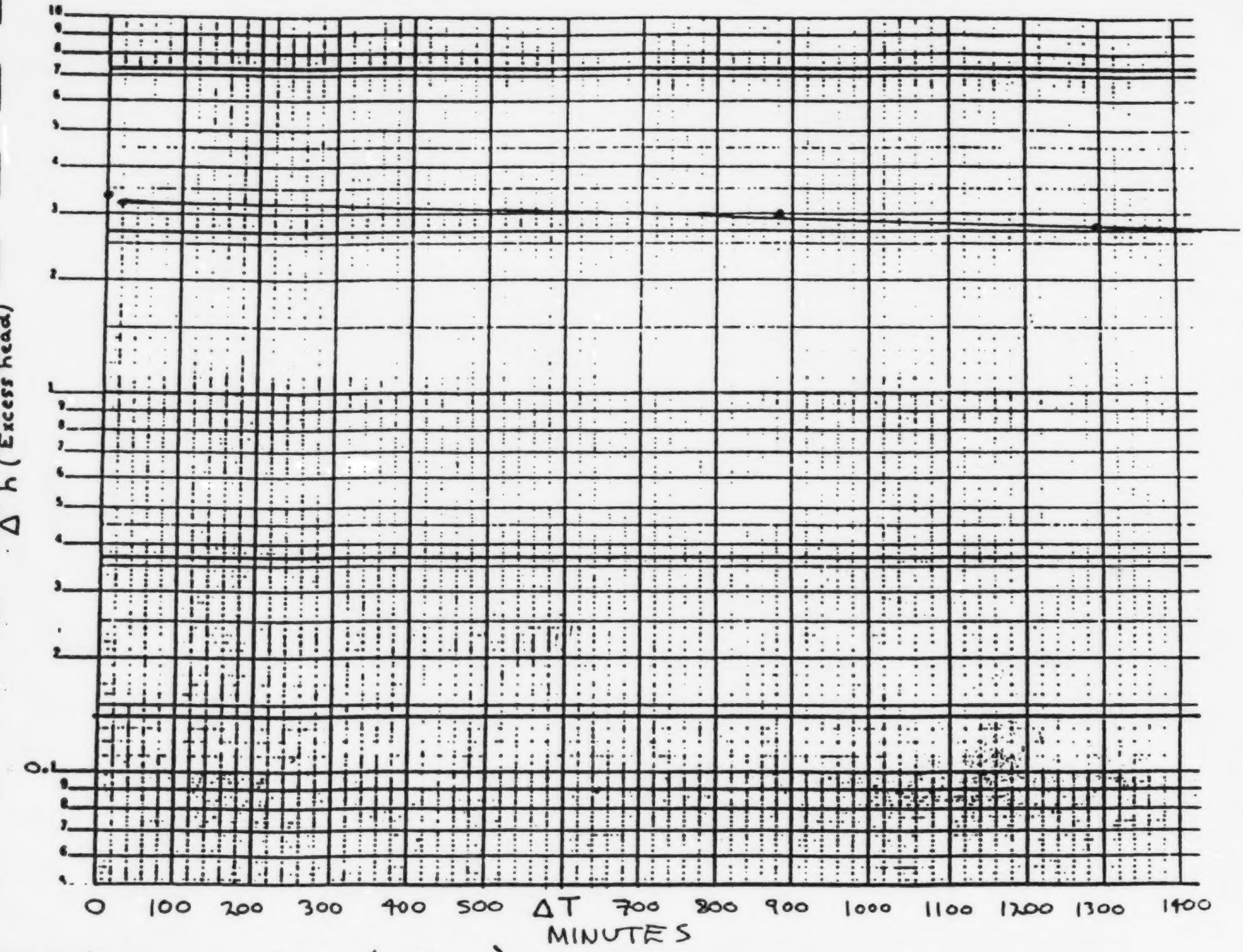
PA-6

Permeability Test Sheet for Test No N P-1 (Bail Test)

Sheet 1 of 2

Test Interval 9.75 to 14.33 (metres)

32 to 47 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln}\left(\frac{2\sqrt{M}}{D} \times L\right)$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.07 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 457 cm (180 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 416,601 seconds

$$K = \frac{5.25^2}{8 \times 457 \times 416{,}601} \text{Ln}\left(\frac{2\sqrt{1}}{15.2} \times 457\right)$$

$K = 7.4 \times 10^{-8}$ cm/sec

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (N-P1)

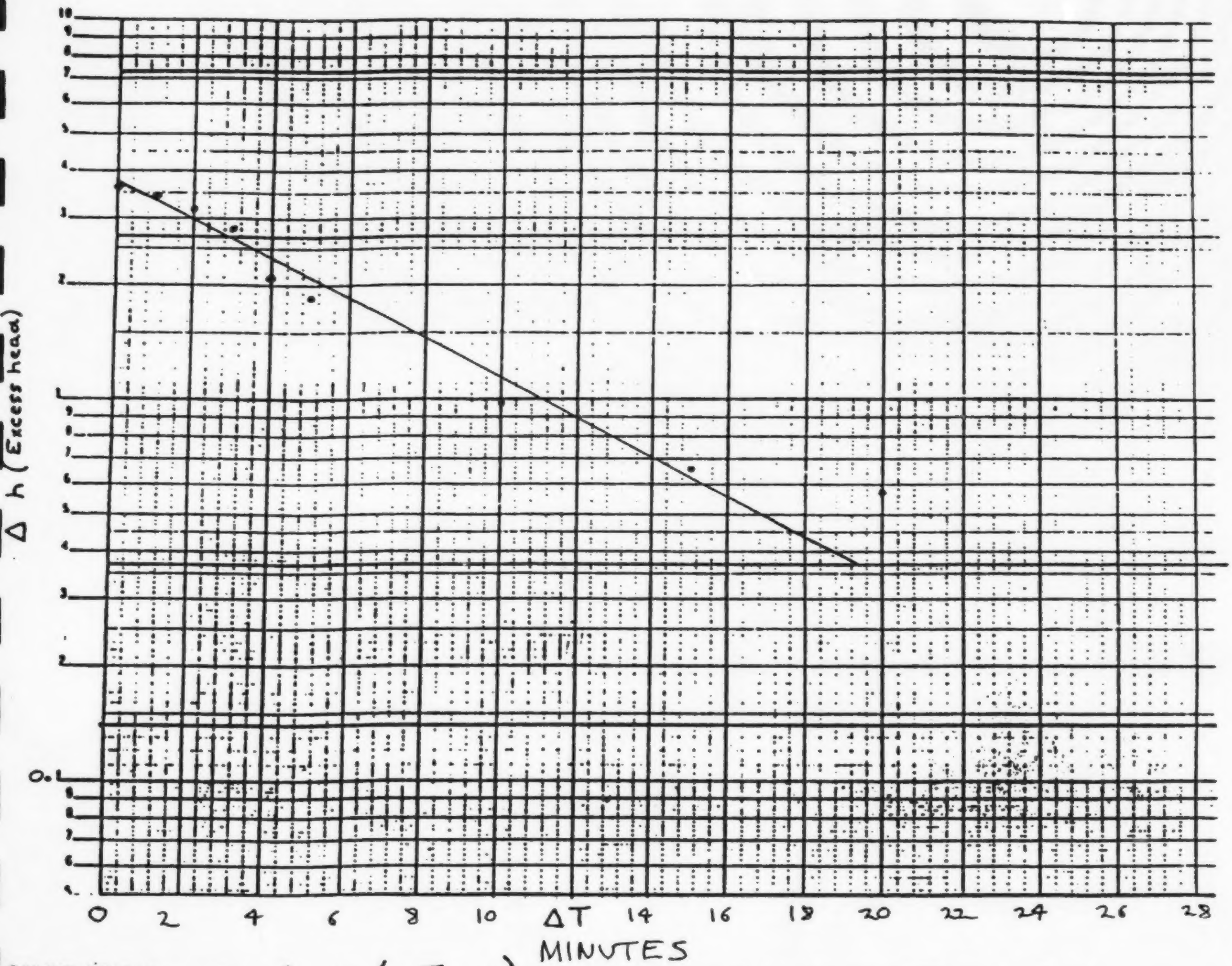
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 10:40 | | 10.33m | | |
| 24 15:40 | | 10.16 | | |
| 15:45 | | 11.35 | | Developed piezometer ⇒ clean water |
| 25 15:42 | | 11.08 | | |
| 26 10:38 | | 10.83 | | |
| 27 17:00 | | 10.52 | | Datum (for hydraulic cond. test) |
| 18:30 | 0 min | 13.87 | 3.35m | Rising Head (Bail) Test |
| | 1 | 13.86 | 3.34 | |
| | 2 | 13.85 | 3.33 | |
| | 3 | 13.82 | 3.30 | |
| | 4 | 13.81 | 3.29 | |
| | 5 | 13.81 | 3.29 | |
| | 10 | 13.77 | 3.25 | |
| | 15 | 13.75 | 3.23 | |
| | 20 | 13.71 | 3.19 | |
| | 30 | 13.68 | 3.16 | |
| 28 9:10 | 880 | 13.50 | 2.98 | |
| 16:05 | 1295 | 13.30 | 2.78 | |
| 29 9:00 | 2310 | 12.79 | 2.27 | |
| 30 9:40 | 3790 | 12.06 | 1.54 | |

PA-6

Permeability Test Sheet for Test No NP-2 (Slug Test) Sheet 1 of 2

Test Interval 2.74 to 3.66 (metres)

9 to 12 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \operatorname{Ln}\left(\frac{2\sqrt{M}}{D} xL\right)$

$$K = \frac{5.25^2}{8 \times 91 \times 480} \operatorname{Ln}\left(\frac{2\sqrt{1}}{15.2} \times 91\right)$$

$K = 2.0 \times 10^{-4}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 91 cm (36 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 480 seconds

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (N-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 10:42 | | Dry | | |
| 24 15:45 | | Dry | | |
| 25 15:45 | | Dry | | |
| 26 10:36 | | Dry | | Datum = 4.04 m |
| 10:50 | 0 min | 0.41m | 3.63m | Falling Head (Slug) Test |
| | 1 | 0.60 | 3.44 | |
| | 2 | 0.88 | 3.16 | |
| | 3 | 1.25 | 2.79 | |
| | 4 | 1.94 | 2.10 | |
| | 5 | 2.18 | 1.86 | |
| | 10 | 3.05 | 0.99 | |
| | 15 | 3.38 | 0.66 | |
| | 20 | 3.46 | 0.58 | |
| | 30 | 3.58 | 0.46 | |
| | 120 | 4.10 | — | |
| 17:15 | 365 | 4.10 | — | |

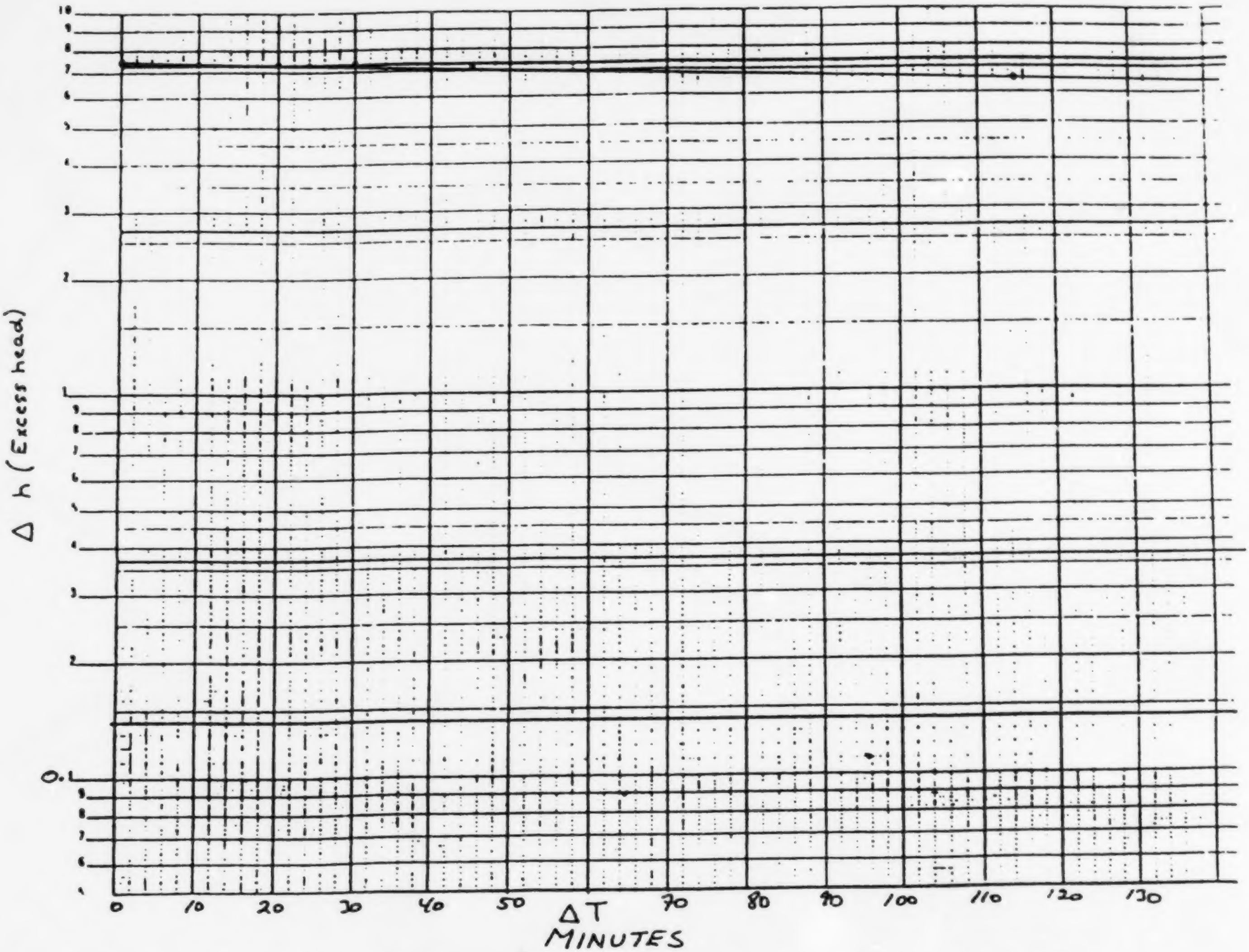
PA-6

Permeability Test Sheet for Test No O P-1 (Bail Test)

Sheet 1 of 2

Test Interval 13.11 to 14.63 (metres)

43 to 48 (feet)



CALCULATIONS: $K = \frac{d^2}{8LT_i} \ln\left(\frac{2\sqrt{M}}{D} \times L\right)$

$$K = \frac{5.25^2}{8 \times 152 \times 61{,}992} \ln\left(\frac{2\sqrt{1}}{15.2} \times 152\right)$$

$K = 1.1 \times 10^{-6}$ cm/sec

where: D = Hole diameter 15.2 cm (6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head (h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 61,992 seconds

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (O-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:03 | | 6.01 m | | |
| 24 15:50 | | 6.00 | | |
| 16:00 | | 12.06 | | Developed piezometer ⇒ clean water |
| 25 15:36 | | 7.72 | | |
| 26 9:43 | | 6.93 | | |
| 10:12 | | 7.98 | | Developed piezometer ⇒ clean water. |
| 17:42 | | 7.31 | | |
| 27 8:30 | | 6.77 | | |
| 12:40 | | 6.66 | | |
| 16:15 | | 6.65 | | Datum (for hydraulic cond. test) |
| 16:30 | 0 min | 14.15 | 7.50 m | Rising Head (Bail) Test |
| | 1 | 14.13 | 7.48 | |
| | 2 | 14.12 | 7.47 | |
| | 3 | 14.11 | 7.46 | |
| | 4 | 14.10 | 7.45 | |
| | 5 | 14.08 | 7.43 | |
| | 10 | 14.04 | 7.39 | |
| | 15 | 14.01 | 7.36 | |
| | 20 | 13.99 | 7.34 | |
| | 30 | 13.96 | 7.31 | |
| | 45 | 13.87 | 7.22 | |
| | 115 | 13.36 | 6.71 | |
| 28 9:05 | 995 | 10.53 | 3.88 | |
| 16:00 | 1410 | 9.86 | 3.21 | |
| 29 8:55 | 2425 | 8.47 | 1.82 | |
| 30 9:35 | 3905 | 7.31 | 0.66 | |

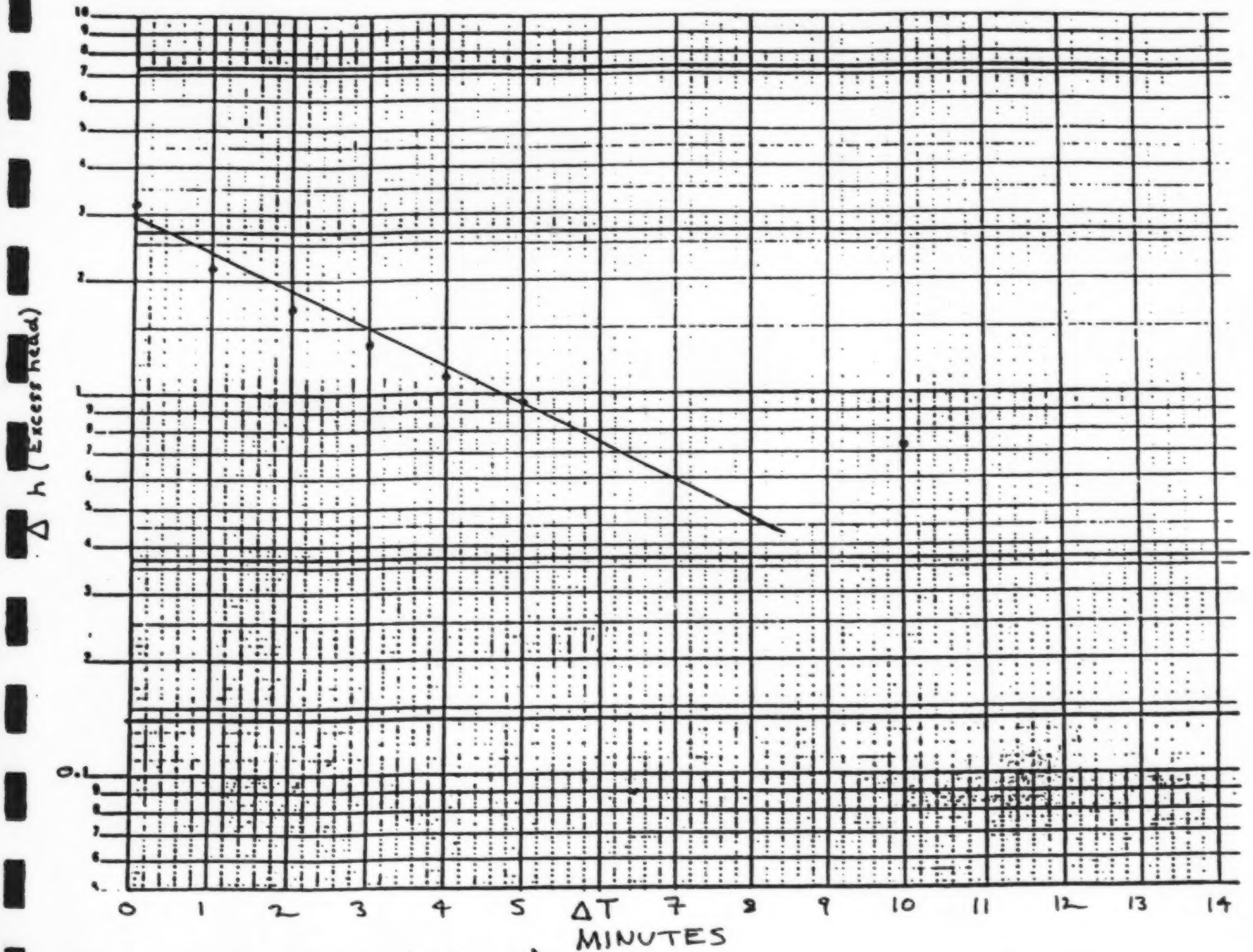
**PA-6**

Permeability Test Sheet for Test No O P-2 (Slug Test)

Sheet 1 of 2

Test Interval 2.74 to 3.66 (metres)

9 to 12 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln} \left( \frac{2\sqrt{M}}{D} \text{x} L \right)$

$$K = \frac{5.25^2}{8 \times 91 \times 288} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 91 \right)$$

$K = 3.3 \times 10^{-4}$ cm/sec

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 91 cm (36 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 288 seconds

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (O-P2)

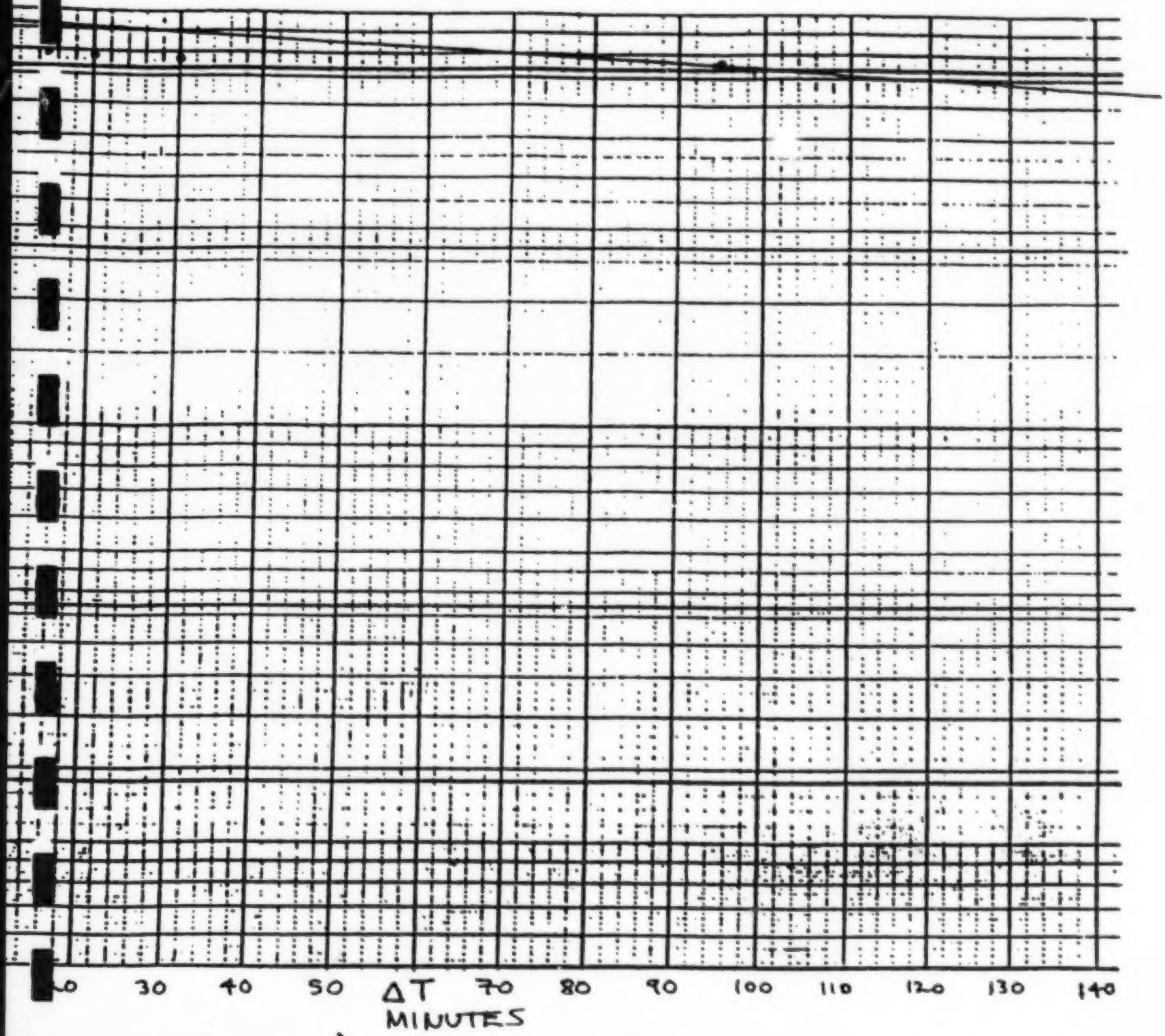
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 23 11:06 | | Dry | | |
| 24 16:10 | | Dry | | |
| 25 15:35 | | Dry | | |
| 26 9:43 | | Dry | | Datum = 3.98 m |
| 10:00 | 0 min | 0.80 m | 3.18 m | Falling Head (Slug) Test |
| | 1 | 1.81 | 2.17 | |
| | 2 | 2.27 | 1.71 | |
| | 3 | 2.64 | 1.34 | |
| | 4 | 2.86 | 1.12 | |
| | 5 | 3.01 | 0.97 | |
| | 10 | 3.25 | 0.73 | |
| | 15 | 3.27 | 0.71 | |
| | 20 | 3.28 | 0.70 | |
| | 30 | 3.28 | 0.70 | |
| | 90 | 3.37 | 0.61 | |
| | 180 | 3.47 | 0.51 | |
| | 360 | 3.58 | 0.40 | |
| | 430 | 3.62 | 0.36 | |
| | 465 | 3.64 | 0.34 | |
| 27 8:30 | 1350 | 3.88 | 0.10 | |
| 12:40 | 1600 | 3.91 | 0.07 | |
| 16:15 | 1815 | 3.93 | 0.05 | |
| 18:25 | 1945 | 3.94 | 0.04 | |

Permeability Test Sheet for Test No P P-1 Sheet 1 of 2

(Slug Test)

1[illegible].78 to 17.83 (metres)

[illegible]8.5 to 58.5 (feet)



$$K = \frac{d^2}{8LTi} \ln\left(\frac{2\sqrt{M}}{D} \times L\right)$$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

$M = K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 305 cm (120 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 46,842 seconds

$$\frac{2[illegible]^2}{305 \times 46{,}842} \ln\left(\frac{2\sqrt{1}}{15.2} \times 305\right)$$

$.9 \times 10^{-7}$ cm/sec

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (P-P1)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug23 10:14 | | Dry | | |
| 25 16:08 | | Dry | | |
| 27 10:05 | | Dry | | Datum = 18.24 m |
| 10:15 | 0min | 8.53m | 9.71m | Falling Head (Slug) Test |
| | 1 | 8.57 | 9.67 | |
| | 2 | 8.62 | 9.62 | |
| | 3 | 8.72 | 9.52 | |
| | 4 | 8.83 | 9.41 | |
| | 5 | 8.97 | 9.27 | |
| | 10 | 10.16 | 8.08 | |
| | 15 | 10.38 | 7.86 | |
| | 20 | 10.40 | 7.84 | |
| | 30 | 10.41 | 7.83 | |
| | 95 | 10.41 | 7.83 | |
| | 170 | 10.43 | 7.81 | |
| | 350 | 10.44 | 7.80 | |
| | 545 | 10.45 | 7.79 | |
| 28 9:25 | 1390 | 10.45 | 7.79 | |
| 16:30 | 1815 | 10.45 | 7.79 | |
| 29 9:20 | 2825 | 10.45 | 7.79 | |
| 30 10:10 | 4315 | 10.46 | 7.78 | |

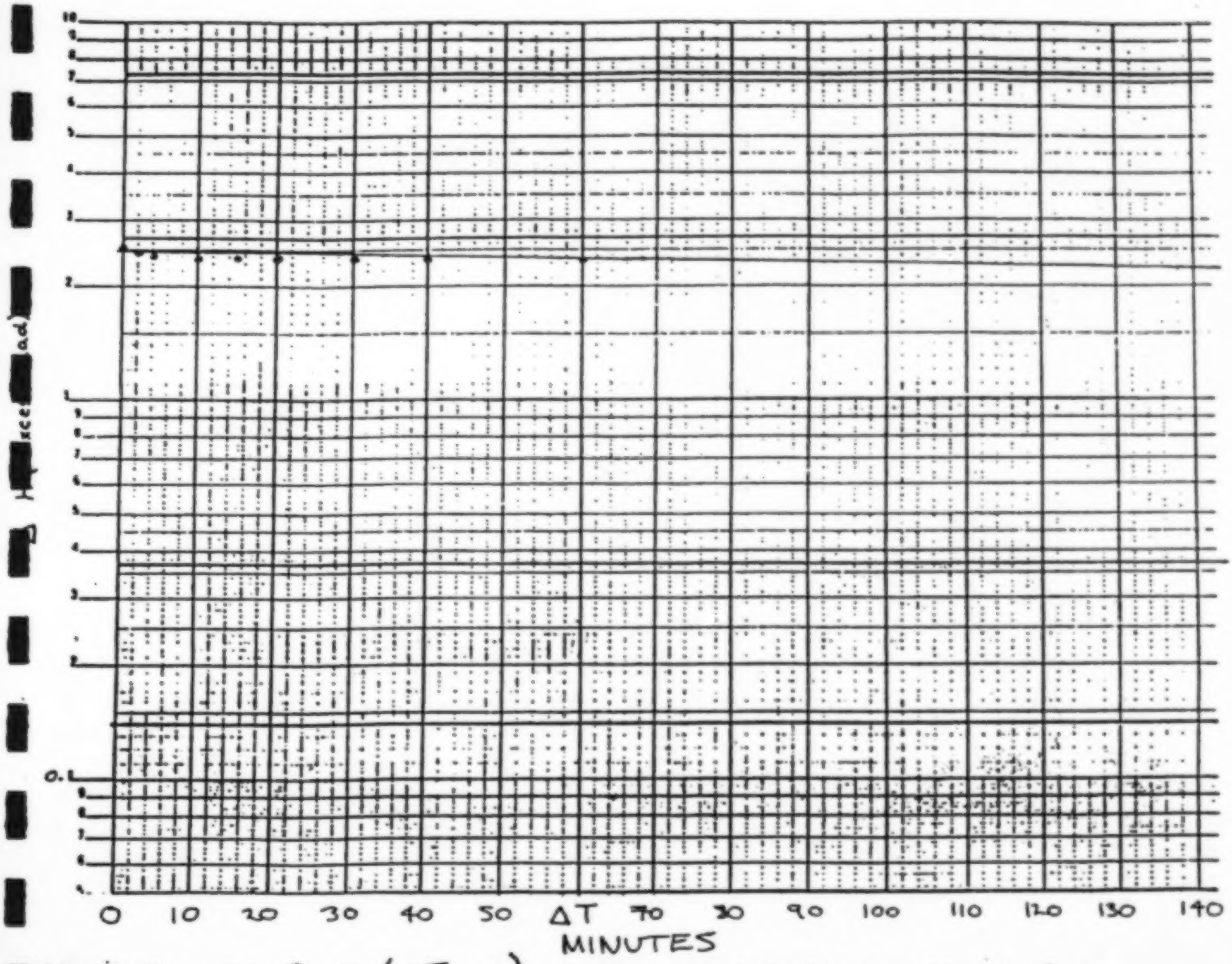
PA-6

Permeability Test Sheet for Test No Q P-1 (Slug Test)

Sheet 1 of 2

Test Interval 1.37 to 2.29 (metres)

4.5 to 7.5 (feet)



CALCULATIONS: $K = \frac{d^2}{8LTi} \text{Ln} \left( \frac{2\sqrt{M}}{D} xL \right)$

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.067 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 91 cm (36 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 980,574 seconds

$$K = \frac{5.25^2}{8 \times 91 \times 980{,}574} \text{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 91 \right)$$

$$K = 9.6 \times 10^{-8} \text{ cm/sec}$$

## GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (Q-P1)

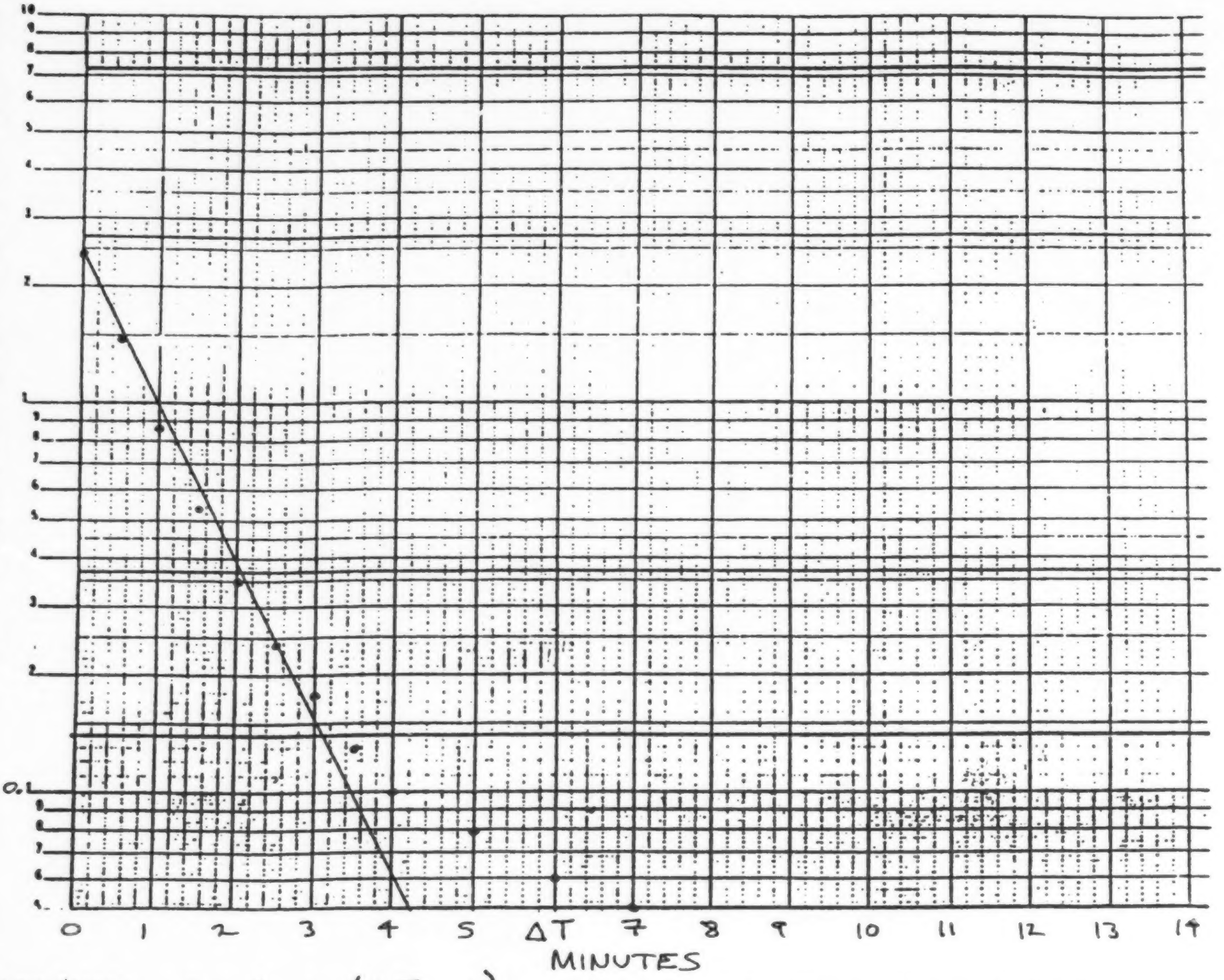
| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug24 15:00 | | Dry | | |
| 25 15:56 | | Dry | | |
| 26 14:40 | | Dry | | Datum = 2.71m |
| 14:45 | 0 min | 0.20m | 2.51m | Falling Head (Slug) Test |
| | 1 | 0.25 | 2.46 | |
| | 2 | 0.27 | 2.44 | |
| | 3 | 0.28 | 2.43 | |
| | 4 | 0.30 | 2.41 | |
| | 5 | 0.30 | 2.41 | |
| | 10 | 0.32 | 2.39 | |
| | 15 | 0.32 | 2.39 | |
| | 20 | 0.33 | 2.38 | |
| | 30 | 0.33 | 2.38 | |
| | 40 | 0.35 | 2.36 | |
| | 60 | 0.35 | 2.36 | |
| | 155 | 0.38 | 2.33 | |
| 27 8:40 | 1085 | 0.53 | 2.18 | |
| | 1330 | 0.56 | 2.15 | |
| | 1415 | 0.57 | 2.14 | |
| | 1510 | 0.58 | 2.13 | |
| | 1675 | 0.60 | 2.11 | |
| 28 9:20 | 2555 | 0.69 | 2.02 | |
| 16:20 | 2975 | 0.72 | 1.99 | |
| 29 9:05 | 3980 | 0.81 | 1.90 | |
| 30 9:50 | 5465 | 0.92 | 1.79 | |

PA-6 Permeability Test Sheet for Test No Q P-2 Sheet 1 of 2

(Bail Test)

Test Interval 6.71 to 8.23 (metres)

22 to 27 (feet)



ALCULATIONS: $K = \frac{d^2}{8LTi} \ \mathrm{Ln} \left( \frac{2\sqrt{M}}{D} \times L \right)$

$$K = \frac{5.25^2}{8 \times 152 \times 66} \ \mathrm{Ln} \left( \frac{2\sqrt{1}}{15.2} \times 152 \right)$$

$K = 1.0 \times 10^{-3}$ cm/sec.

where: D = Hole diameter 15.2 cm ( 6 in)

d = Tube diameter 5.25 cm (2.07 in)

M = $K_H/K_V$ = ANISOTROPY = 1

K = Hydraulic Conductivity

L = Test Length 152 cm (60 in)

Ti = Time Interval for Excess Head ( h) to Decay by 63%

= Time for Excess to Drop from One Bold Line to the Next Bold Line

= 66 seconds

2/2

# GROUNDWATER SAMPLING FIELD RECORD

**PITEAU & ASSOCIATES**
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

Pine Coulee (Q-P2)

| DATE AND TIME | ELAPSED TIME | WATER LEVEL | DRAW-DOWN | REMARKS |
|---|---|---|---|---|
| Aug 24 15:10 | | 3.65m | | |
| 15:15 | | 6.65 | | Developed piezometer ⇒ clean water |
| 25 15:57 | | 2.64 | | |
| 26 15:50 | | 4.04 | | Developed piezometer with $N_2$ purge |
| 17:21 | | 2.39 | | |
| 27 8:40 | | 2.38 | | |
| 11:03 | | 3.10 | | Developed piezometer by bailing |
| 11:05 | | 2.42 | | |
| 12:55 | | 2.38 | | Datum (for hydraulic cond. test) |
| 13:00 | | 4.12 | | |
| 14:30 | 0 min | 4.86 | 2.48 | Rising Head (Bail) Test |
| | 0.5 | 3.85 | 1.47 | |
| | 1 | 3.25 | 0.87 | |
| | 1.5 | 2.92 | 0.54 | |
| | 2 | 2.73 | 0.35 | |
| | 2.5 | 2.62 | 0.24 | |
| | 3 | 2.56 | 0.18 | |
| | 3.5 | 2.51 | 0.13 | |
| | 4 | 2.48 | 0.10 | |
| | 5 | 2.46 | 0.08 | |
| | 6 | 2.44 | 0.06 | |
| | 7 | 2.43 | 0.05 | |
| | 10 | 2.42 | 0.04 | |
| | 85 | 2.39 | 0.01 | |
| | 250 | 2.38 | 0.00 | |
| 28 9:20 | 1130 | 2.37 | — | |
| 16:20 | 1550 | 2.37 | — | |
| 30 9:50 | 2600 | 2.36 | — | |